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THE MIDDLE DEVONIAN OF OHIO

A DISSERTATION SUBMITTED TO THE FACULTY OF THE
OGDEN GRADUATE SCHOOL OF SCIENCE
IN CANDIDACY FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY

Department of Geology

BY
CLINTON RAYMOND STAUFFER

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INTRODUCTION.

It is proposed to bring together, in the following discussion, the more important facts that have previously been published regarding the Middle Devonian formations of Ohio; to discuss the sections and faunas of a number of characteristic outcrops scattered over the entire area of outcrop within the State; to discuss the relationships of the faunas; and to give a few notes on certain species, together with figures and descriptions of certain others which have thus far remained undescribed.

During the progress of this study, encouragement and helpful suggestions have been received from a number of friends and fellow-workers. But more specific mention should be made of Dr. Charles S. Prosser for valuable assistance in the identification of difficult specimens, and for actual accompaniment in some parts of the field, as well as for advice in regard to the general outline of the work; Dr. J. A. Bownocker, whose suggestions and kindly interest have made the burdensome part of the work a much easier task; and especially Dr. Stuart Weller, whose knowledge of species and faunas has been a constant aid. All three of these gentlemen have had a part in the criticism of the manuscript and have thus contributed to the value of the finished work.

Nor would this portion of the report be complete without the mention of Miss Edith Hyde, who did the illustrative work on the fossils. In addition to being an artist, Miss Hyde is a paleontologist and as such has rendered valuable assistance in the case of specimens submitted to her.

C. R. S.

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CHAPTER I.

GENERAL DISCUSSION OF THE MIDDLE DEVONIAN.

HISTORICAL SKETCH.

The Middle Devonian formations of Ohio, lying as they do along the shores of an island in the midst of one of the great Devonian seas, form an interesting and important chapter in the history of that period, and the limestone portions have been a subject of study since the organization of the first Geological Survey of the State.

In the First Annual Report (1838) Kirtland describes "The Great Limestone Deposit," which he says according to Riddell is divided into "the blue limestone district" and "the yellow limestone district," the latter of which extends "from Adams, Highland, Green and Montgomery counties northward to Michigan and Lake Erie, and from the shale regions on the Huron and Olentangy westward, doubtless, beyond the State boundary."[1] As we now know this region includes not only the Devonian limestones, but those of the Silurian as well.

The Second Annual Report appeared the same year, and in it J. W. Foster gave a "Geological Section along the National Road from the Scioto River to the eastern line of Muskingum county, in the State of Ohio," in which he represents a portion of the rocks designated the "Mountain limestone with beds of chert."[2] In his section giving the "Geological Structure," Number VI is named the "Mountain Limestone" which, he says, consists of "Beds of limestone intermixed with chert."[3] And again "The series [shale] last described reposes on a formation composed of beds of limestone to which the terms 'Mountain' and 'Transition' have been applied. The color of this limestone varies from a light gray to blue. It is subcrystalline in its texture, and is stratified in layers from a few inches to three of four feet in thickness, being divided by thin beds of clay or marl. It is also intermixed with chert or hornstone." It outcrops "near the residence of Mr. W. Sullivant, about three miles west of Columbus," and "is the material of which the Penitentiary is constructed."[4] There can be no doubt concerning the mass of rocks here referred to, and yet statements made by Foster in the same connection indicate that he used the above term in a manner synonymous with that of "Cliff limestone" used by Locke for the rocks of the whole "yellow limestone district."[5] The term "Mountain limestone," it will be recalled,

[1] 1st. Ann. Rept., *Geol. Surv. Ohio*, 1838, p. 76.
[2] 2d Ann. Rept., *Geol. Surv. Ohio*, 1838, opp. p. 73.
[3] *Idem.*, p. 76, [4] *Idem.*, p. 106. [5] *Idem.*, p. 211.

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is the name applied by various English geologists to the Carboniferous [Mississippian] limestones occurring in Great Britain. It has subsequently been applied to limestones belonging to that system in various states of the Union. So it would seem that Foster regarded these limestones in Ohio as Mississippian.

Thus it appears that during the pioneer Geological Survey, the Devonian limestones were not differentiated from the older formations belonging to the Silurian, nor from the more recent formations of other states, but this distinction remained for James Hall who first identified the "Corniferous limestone" in Ohio.[1] In referring to this fact, he says: "A short distance to the west of that place [Columbus], the Corniferous limestone of New York appears, presenting its characteristic fossils. This mass is the upper part of the Cliff limestone formation of Dr. Locke, the name by which it is generally known in Ohio. The localities where I saw this rock exhibited less hornstone than is usual in New York, but the position and fossil characters were unequivocal."[2] This definite statement by so eminent a geologist must have meant much to those directly interested in the geology of our State, for, so far as now appears, it was the first real truth that had been uttered concerning the correlation of Ohio formations with those of the East, and probably served as the gateway through which other facts became known.

In the middle forties de Verneuil studied the Devonian deposits of Indiana and Kentucky, and in his discussion of the correlation of these formations with those of New York says that "in the states of Ohio, Indiana and Kentucky it [Devonian] is reduced to the black schists which represent the Genesee slate, and to a calcareous band which represents at once the Corniferous and Onondaga limestones and the Hamilton group of the state of New York."[3] He thus supports Hall's conclusions.

Newberry, Chief Geologist of the Second Geological Survey of Ohio, accepted Hall's correlation and under his direction the "Corniferous" was studied in some detail appearing with the above name on his "Preiminary Geological Map of Ohio,"[4] and in the accompanying report he describes it together with a mention of some of its fossils.[5] Again in the first volume of the Geological Survey of Ohio he gives a rather complete description of the "Corniferous," dividing it into two well marked divisions. "Of these the uppermost is a blue, thin bedded limestone, from fifteen to twenty feet in thickness, and is the rock quarried at Sandusky and Delaware. This I have usually designated as the Sandusky limestone.[6] Below this we find a very light-colored limestone which

[1] *Geol. Sur. Ohio*, Vol. I, pt. 1, 1873, p. 142.
[2] *Geol. N. Y.*, pt. IV, 4th Dist, 1843, p. 503.
[3] Hall's translation, *Am. Jour. Sci.* 2nd Ser. Vol. V, 1848, p. 370.
[4] *Geol. Surv. Ohio, Rept. Prog. for* 1869, (1870), opp. title page.
[5] *Idem*, p. 17.
[6] See Dr. Prosser's article on the Delaware limestone, *Jour. Geol.*, Vol. XIII, 1905, pp. 425-442, and his historical review of the Devonian limestones in Ohio on pp. 413-425.

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often contains balls and masses of chert. It is strikingly different in its mineral character, and somewhat different in its fossils from the overlying bed; though a large number of species are common to both. This lower subdivision I have called the Columbus limestone, as it is the rock opened in the quarries near that city."[1]

In N. H. Winchell's report on the Geology of Crawford county, a similar statement is found. He says that "It [Corniferous] is distinctly divisible, on paleontological and lithological differences, into two parts, the upper part embracing the blue limestone, which shows some relations to the Hamilton, and the lower part embracing the light-colored and dolomitic limestones * * * . The former * * * is extensively wrought at Delaware and Sandusky. The latter is quarried at Marblehead * * * and at Columbus."[2]

It is evident, therefore, that both of these men were impressed by the different characteristics exhibited by the two portions of the terrain, but there was a decided difference of opinion as to the upper or so-called "Sandusky limestone." Winchell considered it as representing a portion of the New York Hamilton. He had been connected with the Michigan Geological Survey, where the Traverse group is rather definitely correlated with the Hamilton of the East, and out of the twenty-three Ohio counties represented to have exposures of the Devonian limestones, Winchell studied and reported on fifteen, while the other eight county reports are the work of five different men. As a consequence he must have had abundant opportunity to examine the formations in their various phases of outcrop. Concerning the upper limestone, or that which we now know as the Delaware, he remarks that "Hamilton fossils prevail over those having a distinctive Corniferous character, both in Michigan and in Ohio throughout this blue limestone."[3] Newberry on the other hand regarded it as the upper portion of the "Corniferous." He had examined carefully the exposures of Erie county and made a general investigation of the outcrops of other portions of the state. Concerning these he says, "In all the exposures, however, which I have examined of this member [Upper Corniferous] of the series, I have found Corniferous fossils greatly predominating, and the truly Hamilton species confined to the uppermost layers."[4] These statements, and many others of a similar nature made by the same scientists, are conflicting, even contradictory, but are readily understood when we consider the fact that the two gentlemen were, in reality, discussing two different limestones, thus making it possible for both to be, in a measure, correct. Newberry took as his type section that found at the quarries in the vicinity of Hancock street and Sycamore line, Sandusky, which, with the exception

[1] *Geol. Surv. Ohio*, Vol. I, pt. 1, 1873, p. 143.
[2] *Idem.* Vol. II, pt. 1, 1874, p. 244.
[3] *Proc. Am. Ass'n. Adv. Sci.*, Vol. XXII, pt. 2, 1874, p. 102.
[4] *Geol. Surv. Ohio*, Vol. I, pt. 1, 1873, p. 151.

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of the uppermost layers, has since been shown to be Columbus limestone.[1] Winchell based his conclusions on the section at Delaware, but probably more especially on the outcrops of the northwestern part of the state; his study was therefore of a formation lying above that to which Newberry referred, or of the true Delaware limestone. Perhaps, however, Winchell was carrying his correlation ideas rather far when he introduced the name Tully limestone,[2] for the top layers, at most "about nine and one-half feet" of the "Upper Corniferous."

In his "Report on the Geology of Franklin County," Orton, who agreed in general with the Newberry classification, speaks of the upper part of the "Corniferous" as "the blue limestone, thirty-two feet in thickness, which is, from its occurrence at Delaware, and the extensive use made of it at that point, well named the Delaware limestone."[3] Winchell had used this term four years earlier for the same mass of rocks,[4] but regarding this use he says: "I used the term Delaware stone or Delaware limestone as a constituent of the geology of Delaware county only, although I referred to its extension (paleontologically at least) northward to Sandusky county. The idea that it would ever be used as a formational name, even for the county, was not in my mind."[5] Prosser has credited the name to Orton,[6] who appears to have given it a definite formational meaning. In referring to the correlation of the Ohio with the New York Devonian, Orton says: "The Devonian limestones * * grew in a sea in which the same general conditions were maintained, while very different strata were in process of formation at the East. The Columbus and Delaware limestones probably cover the age in which the Corniferous limestone, and the Hamilton group, in part, of New York were forming; * * * A disturbance of previous conditions took place in this interior sea, which is marked by the change from the Columbus limestone to the Delaware limestone, but any correlation of this change, with epochal changes at the eastward, is, so far as the facts appealed to indicate, entirely arbitrary."[7] We thus see that while Orton sympathized with the position which Winchell had taken, he did not consider a definite correlation possible.

While discussing the outcrops of the Devonian limestones at the

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[1]Prosser, Charles S., *Jour. Geol.*, Vol. XIII, 1905, p. 441; also Swartz, Charles K., *Johns Hopkins Univ. Cir. N. Ser.*, No. 7, 1907, p. 56.

[2]*Geol. Surv. Ohio*, Vol. II, pt. 1, 1874, pp. 240, 288, 291, etc.

[3]*Idem*, Vol. III, 1878, p. 606.

[4]*Idem*, Vol. II, pt. 1, 1874, pp. 294, 295.

[5]Letter of Feb. 1st, 1906.

[6]*Geol. Surv. Ohio*, 4th Ser., Bull. No. 7, 1905, pp. 3, 24.

[7]*Geol. Surv. Ohio*, Vol. III, 1878, pp. 633, 634.

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Falls of the Ohio, James Hall says that "in the state of Ohio, Dr. Newberry recognizes the following:

Corniferous group { Hamilton shale. / Hamilton limestone. / Sandusky limestone. / Delhi beds. / Columbus limestone."[1]

Just what the significance of such a classification[2] may be, is somewhat problematic, since in the section at Prout Station the "Hamilton limestone" lies above the "Hamilton marl."[3] It is very certain that Newberry did not then refer to the Delaware when he used the term "Hamilton limestone." Hall probably misquoted Newberry, and yet the error, if such it be, was made on the side of truth.

Finally R. P. Whitfield, who visited Ohio in 1878 and made some geological excursions with Orton, found a bed of dark brown shale forming the base of the Delaware limestone along Slate Run six miles northwest of Columbus, and likewise on the east bank of the Scioto nearly opposite the village of Dublin. In this shale he collected a fauna which led him to declare it to be "the equivalent of the Marcellus shale of New York."[4] Charles S. Prosser says that this is "the most important discovery relating to the classification of the Devonian limestones that had been made in central Ohio."[5] If this identification is correct, it settles at once the limitations of the "Corniferous" proper and the necessary Hamilton age of the Delaware limestone. Concerning this occurrence of the Marcellus shale, Whitfield himself says: "The geological importance of this formation among the rocks of Ohio, may not be readily recognized; but, forming as it does, a dividing line between the lower and upper Devonian, as between the limestone of the Upper Helderberg and those which are properly referable to the Hamilton period, it will have great value."[6] But so great had been the opposition to this correlation that even Whitfield's conclusion, although restated in the Geology of Ohio,[7] was not well received.

In order to lessen the objections made by various geologists to the classification then in use, Orton introduced the New York term "Upper Helderberg limestone," which he considered "a more comprehensive term."[8] Prosser, however, says that "the substitution of the name 'Upper Helderberg limestone' for 'Corniferous limestone' did not meet any of the objections raised by Winchell, Hall and Whitfield to the New-

[1] *Pal. N. Y.*, Vol. V, pt. II, 1879, p. 141.
[2] *Geol. Surv. Ohio*, Vol. VI, 1888, pp. 763, 766.
[3] *Geol. Surv. Ohio*, Vol. II, pt. 1, 1874, p. 190.
[4] *Proc. Am. Ass. Adv. Sci.*, Vol. XXVIII, 1879, p. 298.
[5] *Jour. Geol.*, Vol. XIII, 1905, p. 418.
[6] *Op. cit.*, p. 299.
[7] *Geol. Surv. Ohio*, Vol. VII, 1893, pp. 432-433.
[8] *Geol. Surv. Ohio*, Vol. VI, 1888, p. 20.

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berry classification of the Devonian limestones of Ohio, because, so far as the later formations are concerned, it is not a more comprehensive term than the 'Corniferous limestone,' and in its classic locality, the Helderbergs of eastern New York, has never been applied to rocks above the base of the Marcellus shale."[1] Indeed the matter became so much the more complex by the appearance in the State geological literature of another name representing the same formations.

Bownocker, in his paper on "The Paleontology and Stratigraphy of the Corniferous Rocks of Ohio," while discussing the "Relation of the Fauna above the Bone-bed to that Below," at the various places visited, states that "this difference is most conspicuous at Delaware and diminishes to the north, being least at Sandusky."[2] It is quite probable, however, that at the time of his writing the "bone-bed" had not been definitely located at the latter place, as his collection from the "upper limestone" was made from the quarries near Hancock street and Sycamore line, and hence from the Columbus limestone.

In 1889 Newberry published a paper, entitled "Devonian Plants from Ohio," in which he mentions "the Delaware limestone, the upper division of the Corniferous" and again "the white or Sandusky limestone below."[3] About six years later James D. Dana published the fourth edition of his Manual and in it, while referring to the occurrence of the "Corniferous" in Ohio, he says, "two divisions are made out—the lower, named the Columbus or Sandusky, and the upper, the Delaware limestone."[4] In this it seems certain that Dana was following Newberry, since he calls both of these limestones "Corniferous," which under the other classification would probably not have been done. These statements seem to indicate that Newberry had yielded his earlier opinion regarding the rocks at Sandusky and now correlated them with the Columbus limestone, or lower division of his "Corniferous" instead of with the Delaware limestone as he had heretofore done. Charles K. Swartz, who has made a rather extensive study of the Ohio Devonian limestones, has also referred most of the rocks of Newberry's "Sandusky limestone," in the vicinity of the city of which it bears the name, to the Columbus limestone.[5] This correlation has been verified and, in the main, accepted by Prosser,[6] who, in his "Revised Nomenclature of Ohio Geological Formations," uses Columbus and Delaware as the formational names for these limestones.[7]

Hayes and Ulrich give a correlation table in the last column of

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[1] *Jour. Geol.*, Vol. XIII, 1905, p. 420.
[2] *Bull. Sci. Lab. Den. Univ.*, Vol. XI, 1898, p. 39.
[3] *Jour. Cin. Soc. Nat. Hist.*, Vol. XII, 1889, p. 49.
[4] *Dana's Man. of Geol., 4th Ed.*, 1895, p. 581.
[5] *Loc. cit.*, p. 56.
[6] *Jour. Geol.*, Vol. XIII, 1905, p. 441.
[7] *Geol. Surv. Ohio, 4th Ser., Bull. No. 7*, 1905, pp. 3, 24, 25.

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which, under the head of "Geological Survey of Ohio, 1873-93," they give the following for the Devonian:

"Black or Ohio shale (1893).
(Including Cleveland shale, Erie shale and Huron shale.)
Olentangy shale and Delaware limestone.
(Hamilton.)
Columbus limestone.
(Corniferous.)"[1]

No discussion follows, but of course they have followed Winchell and Whitfield.

During the same year (1903) Edward Claypole's article on "The Devonian Era in the Ohio Basin" appeared. He states that "the planes of division between these groups—the Corniferous and Hamilton—are less sharp in Ohio than in New York, where the transition from the pure limestones of the Corniferous to the black shales of the Hamilton is comparatively abrupt."[2] He therefore calls the Delaware limestone "Corniferous-Hamilton" and says "the facts warrant the statement that Corniferous conditions prevailed in Ohio throughout the whole of the Hamilton period in New York, with a few temporary and local interruptions."[3] He correlates the shaly zone at the base of the Delaware with the Marcellus shale,[4] thus bringing in, at least in some parts of the state, a return of "Corniferous" conditions after the deposition of that formation.

Grabau relieves us somewhat regarding the idea that the Hamilton shales of the East must necessarily be represented by shales in the West. While discussing the Eighteen Mile Creek sections, and especially the Encrinal limestone, he remarks that "in Illinois, Iowa, Michigan, Ohio, Indiana and other central states, however, the Hamilton is chiefly represented by limestones, often of considerable thickness."[5] The only Ohio limestone, of any "considerable thickness," that may be classed as Hamilton is, of course, the Delaware and we might infer that he had it in mind when writing the above statement were it not for the rather misleading remark that "the 'black shale' of Ohio and other states represents these deposits [Marcellus], which continued uniformly during all the time that the Hamilton beds were being laid down over New York."[6]

"The Traverse fauna," Schuchert says, "is a commingling of Mississippian and Dakota species. This mixed Middle Devonic fauna is continued southward as far as Louisville and Lebanon, Kentucky, on the west side of the Cincinnati island, while immediately on the eastern side of this island at Columbus, Ohio, the faunal sequence is more decidedly

[1] *U. S. Geol. Surv.*, Columbia folio, No. 95, 1903.
[2] *Am. Geol.*, Vol. XXXII, 1903, pp. 34, 35.
[3] *Idem*, p. 36.
[4] *Idem*, p. 35.
[5] *Bull. Buf. Soc. Nat. Sci.*, Vol. VI, No. 1, 1898, p. 80
[6] *Idem*, p. 82.

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that of New York. The paleontologic work of Whitfield on the Devonic beds of central Ohio shows unmistakably that the succession here is in agreement with western New York, i. e. the Manlius is followed by the Onondaga, Hamilton, Portage and Chemung faunas. In other words, the New York Hamilton fauna retains its characters more strongly along the shores of Laurentia, Appalachia and the eastern side of the Cincinnati island, while the Traverse Hamilton fauna followed the eastern shore of the Kankakee peninsula and the western side of the Cincinnati island."[1] Schuchert's position is thus decided and unmistakable, as is also that of Weller, who states that "in Ohio the [Corniferous] fauna occurs in the Columbus limestone,"[2] thus distinctly separating that formation from the Delaware. Prosser writes that "the Sandusky (Delaware) limestone ought to be correlated with rocks of later age than the Onondaga limestone, viz: the lower part of the Erian series of New York."[3] Foerste remarks that "in Ohio, on the eastern side of the geanticline, the Sandusky or Delaware limestone has been identified as the lower part of the Erian."[4] More recently, however, this same author says that "in Ohio these [Devonian] limestones include, in descending order:

c. Delaware limestone.
b. Columbus limestone.
a. A comparatively unfossiliferous section of limestone for which no distinctive name has been proposed as yet.

For these three Devonian limestones of Ohio the name Scioto limestone would be very appropriate."[5] It is obvious that if the Delaware limestone belongs to the Erian series it should not be united under one formational name, with the Columbus limestone which is a representative of the Ulsterian series. As to his lower unnamed division "a" of the Columbus limestone, there seems to be insufficient reason for separating it, if he means to make a distinct formation, since its meager fauna is that of the remainder of the formation as at present defined. Schwartz has made three divisions of the Columbus limestone, but he uses them consistently as subdivisions which are not of formational rank, although he does propose names for each.[6]

The Devonian shales of Ohio have never received the same amount of attention in literature as have the limestones. They have not passed through the conflict of opinions that has characterized the limestones, but have gone more directly to their present correlation. While discussing the geological sections of Ohio, Newberry refers to "a band of bluish marly limestone, * * * resting upon the Corniferous lime-

[1] *Am. Geol.*, Vol. XXXII, 1903, p. 148.
[2] *Jour. Geol.*, Vol. X, 1902, p. 424.
[3] *Jour. Geol.*, Vol. XI, 1903, p. 537; also *Geol. Surv. Ohio, 4th Ser., Bull. No. 7*, 1905, p. 24, Note 21.
[4] *Jour. Geol.*, Vol. XI, 1903, p. 702.
[5] *Geol. Surv. Ky., Bull. No. 7*, 1906, p. 12.
[6] *Op. cit.*, pp. 63-65.

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stone where that is overlaid by more recent rocks. From this marly limestone we have obtained many of the characteristic fossils of the Hamilton group."[1] This deposit occupies the same horizon as the blue shale which Winchell discusses in the report on Delaware county, and which he says "has been regarded the equivalent of the Hamilton. There are no fossils in this underlying shale at Delaware proving its Hamilton age, and it will be referred to * * * , to avoid a possible misuse of terms, as the Olentangy shale."[2] This shale at the type section (a quarter of a mile below the railroad bridge over the Olentangy River at Delaware) contains a number of layers of marly limestone and, although nearly destitute of fossils, is doubtless the equivalent of the marly limestone to which Newberry refers, as well as of his Hamilton limestone and marl at Prout Station and Deep Cut[3] near Sandusky.

THE MIDDLE DEVONIAN IN ADJOINING TERRITORY.

In the adjoining state of Indiana, the Middle Devonian limestones have long been correlated with eastern formations.[4] Edward M. Kindle, who has made a systematic study of these outcrops in Indiana, recognizes three distinct formations. In the order of their natural sequence they are as follows: The *Geneva limestone*, which "is generally a massive light buff to chocolate brown saccharoidal magnesian limestone" in which "fossils are extremely rare at most localities * * * and occur usually as casts when found;"[5] the *Jeffersonville limestone*, a very fossiliferous "gray or bluish gray crystalline or subcrystalline limestone, occurring both as a massive and a thinly stratified limestone;"[6] and finally the *Sellersburg beds*, also quite fossiliferous and comprising "a bed of fine grained argillaceous drab grayish-colored limestone * * * and a thin bed of light gray or bluish crystalline limestone above it."[7]

In discussing the "Correlation of faunas" in the last two of these formations as found in the southern Indiana district near the Ohio River, Kindle says: "The Corniferous fauna of New York suffers no very important modifications in its western extension. The large number of species common to the faunas of the Corniferous limestone of New York and the Jeffersonville limestone, especially among the Corals, leaves no doubt as to the equivalence of the two faunas. * * * In southern Indiana we find in the Sellersburg beds a fauna containing many of the most characteristic species of the Hamilton of New York. * * * This fauna is not mingled with the Corniferous as was once supposed, but occurs above that fauna in the Sellersburg beds. The presence in it of such characteristic Hamilton fossils as those mentioned seems to

[1] *Geol. Surv. Ohio, Rept. Prog. 1869*, (1870), p. 18.
[2] *Geol. Surv. Ohio*, Vol. II, pt. 1, 1874, p. 284.
[3] *Geol. Surv. Ohio*, Vol. II, pt. 1, 1874, pp. 189, 190.
[4] Hall, James, *Pal. N. Y.*, Vol. V, pt. 2, 1879, pp. 139-154.
[5] *25th Ann. Rept. Dept. Geol. and Nat. Res. of Ind.*, 1900, p. 535.
[6] *Ibid*, p. 535.
[7] *Ibid*, p. 533.

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leave no doubt of its equivalence to the New York Hamilton."[1] He adds later that "In the northern part of the southern Indiana area these two formations cease to be sharply differentiated lithologically and merge into each other in a limestone which is neither so pure as the Jefersonville limestone nor so argillaceous as the Sellersburg beds near the Falls. Associated with the loss of individuality of these two formations occurs a mingling of their two faunas which renders them indistinguishable as separate faunas." But "in the Wabash area the faunas of the Devonian limestones are even more distinct than that at the Falls of the Ohio."[2]

At the Ohio River the Geneva limestone has thinned out, but the upper two formations may be traced across into Kentucky at Louisville, where the cement layers of the Sellersburg beds furnish the material for a large industry, while in the upper part of the cliffs near the east-side waterworks the Jeffersonville limestone may be seen. The total thickness of the Devonian limestones in Kentucky is reported as about forty feet, although usually much less, and "In outcrop they follow on the map the outcrop of the Devonian Black shale from the Ohio River in Lewis county around to the Ohio River again at Louisville, at which place they form the falls in the river."[3]

In Michigan two divisions are recognized; the Dundee, a gray subcrystalline limestone varying from massive to comparatively thin bedded layers abounding in fossils, and the Traverse, which is more or less impure, frequently being largely shale and attaining a considerable thickness in the northern part of the lower peninsula. These formations are correlated with those of New York in the following manner:

New York	Michigan
Hamilton beds Marcellus shale	Traverse group
Onondaga limestone Schoharie grit Esopus grit	Dundee limestone
Oriskany beds	(hiatus?)[4]

These same formations cross over into Ontario, Canada, near the city of Detroit and blend with the great deposits to the north, where they become materially thickened. Here also two divisions are recognized; the Corniferous limestone which "appears in Canada to have a thickness of about one hundred and sixty feet, and is estimated by Sir William Logan to cover an area of probably not less than six or seven thousand square miles. * * * Throughout almost its whole extent it is richly fossiliferous,"[5] and the Hamilton group which "In Canada * * * is well represented by argillaceous and cal-

[1] *Bull. Am. Pal.*, Vol. III, No. 12, 1899, p. 110.
[2] *25th Ann. Rept. Dept. Geol. and Nat. Res. Ind.*, 1900, p. 570.
[3] *Geol. Surv. Ky., Bull. No. 1*, Prelim. Pt., 1904 (1905), pp. 34, 35.
[4] *Geol. Surv. Mich.*, Vol. VII, pt. 1, 1900, p. 37.
[5] *Rept. Pal. Prov. Ont.*, 1874, p. 9.

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carcous shales with intercalated beds of limestone, the whole having an estimated thickness of about three hundred feet."[1] These Nicholson has correlated with the New York formations in the following manner:

"State of New York	Equivalent in Ontario
Onondaga limestone Corniferous limestone	Corniferous limestone
Marcellus shale Hamilton shales Tully limestone	Hamilton group."[2]

Thus Ohio is in the midst of a region within which true Onondaga and Hamilton deposits are identified. The sum total of previous work on the Middle Devonian within the state has been more or less unsatisfactory, in so far as published records show. It remains, therefore, to bring out the results of a rather extensive investigation of the outcrops of these formations in different parts of the state.

GENERAL DESCRIPTION OF THE MIDDLE DEVONIAN.

The Devonian is represented in Ohio by the Middle and Upper divisions only. These, with their associated formations, are at present classified in the following manner:

Mississippian	Upper			
	Middle			
	Lower	Waverly	Logan formation	
			Black Hand formation	
			Cuyahoga formation	
			Sunbury shale	
			Berea grit	
			Bedford shale	
Devonian	Upper	Chautauquan and Senecan	Ohio shale	Cleveland sh.
				Chagrin form.
				Huron shale
	Middle	Erian	Olentangy shale	
			Delaware limestone	
		Ulsterian	Columbus limestone	
	UNCONFORMITY			
Silurian	Upper	Cayugan	Monroe form.	Lucas ls.
				Sylvania ss.
	Middle			Tymochtee form.
	Lower			

[1] *Rep. Pal. Prov. Ont.*, 1874, p. 9. [2] *Idem*, p. 10.

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South of Pickaway county the limestones of the Middle Devonian, and even the upper part of the Silurian, drop out, so that the Olentangy shale comes to lie upon the Niagaran limestones, while at some places in Pike county even the Olentangy is absent and then the black shale rests directly on the Niagaran.

The Middle Devonian formations, occupying the lower portion of the Devonian System in Ohio, form a belt of outcrop along either side of the Cincinnati anticline, with an outlying portion in the vicinity of Bellefontaine.[1] The eastern of these belts, which has an average width of about ten or twelve miles, extends from the islands in Lake Erie, north of Sandusky, southward to the Ohio River and beyond, although the limestones disappear in Pickaway county. This belt of outcrop is by far the more important both from an economic and a purely scientific point of view, because it is a source of great quantities of lime, crushed stone, furnace flux, and building stone, and its lower member, the Columbus limestone, contains one of the richest faunas found within the borders of the state and probably not excelled by any other Devonian deposit. In Franklin and Delaware counties the Scioto and Olentangy Rivers have cut through the drift and into these formations, while northward the drift is thin and quarries have been opened in the limestones at numerous localities; hence the opportunities for their study are abundant.

The Bellefontaine district consists of a rather broad belt of outcrop surrounding the Ohio shale capped hills extending from the southern portion of Hardin county across Logan and into Champaign county. It is probably one great mass of limestone in the central part, with several detached portions to the north and to the south of the main body. Much of it, especially the upper layers of the Columbus and the entire Delaware (?) formation, appears sandy, hard and compact. The Olentangy shale is wanting. It is quite probable that this outcrop was once a part of the belt through the central portion of the state, that it represents deposits near the old shore line, and that it has since been isolated by preglacial and glacial erosion.

In the northwestern part of the state, and beyond the anticline, lies a somewhat crescent-shaped area of outcrop with a maximum width of about twelve miles. Beginning at the Michigan-Ohio line in Lucas county, it sweeps around to the Ohio-Indiana line near Antwerp, Paulding county. The rocks in this belt have a general dip to the northwest, but the glaciated surface is comparatively horizontal and so near drainage level that extensive outcrops are exceptional.

These belts of outcrop are not to be looked upon as separate, but rather as portions of a continuous shore-line, which can also be picked

[1]See Dr. Bownocker's article, *Bull. Sci. Lab. Den. Univ.*, Vol. XI, 1898, p. 13.

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up at various places in Ontario, Michigan, Indiana and Kentucky, around an island or peninsula in the Devonian sea the nucleus of which was the Cincinnati anticline.

The Middle Devonian of Ohio naturally falls into three divisions, of which the lowermost is known as the Columbus limestone, the middle as the Delaware limestone and the upper as the Olentangy shale. This division is based on both lithological and faunal differences which in some respects are more apparent in the vicinity of Columbus, although not wanting in any of the belts of outcrop. The thickness of each of these three formations varies through a considerable range in different parts of the state.

The Columbus limestone presents two rather persistent lithological differences which are excellently illustrated in the outcrops along the Scioto River, and are not absent even in the northern sections. These two phases of the formation sometimes blend with each other, but occasionally localities are found where the change is abrupt and the characteristics of each portion decided.

The lower portion of the Columbus limestone consists of a rather porous massive brown limestone frequently containing a large amount of bituminous matter and very little chert, but generally having numerous cavities or pockets filled with crystals of calcite. At some places near the base it has been observed to have a pitted or honeycombed structure. It sometimes shows a strong oblique jointing and frequently few definite bedding planes. A fresh surface shows a saccharoidal appearance, but occasionally glistens with cleavage faces of calcite. There is also a tendency to a banded structure which may be seen in the blocks of most, if not all, exposures in central Ohio. This banding, frequently of a wavy appearance, seems to be due to the presence of finely divided bituminous matter. The fossils, except in the extreme upper and lower parts, are poorly preserved and rather rare in most localities. Chemically the limestone from this part of the formation is found to be high in its percentage of magnesium. A sample from Dublin yielded forty-one and seven hundredths per cent. of magnesium carbonate,[1] while several from Bellefontaine gave even a higher percentage for this constituent.[2]

The upper part of the Columbus limestone, which includes about two-thirds of the formation, consists, in the main, of light gray limestone in even beds varying from a few inches to several feet in thickness. At places it contains a considerable amount of white or light gray fossiliferous chert, which is mainly restricted to a few zones, where it occurs in concretionary masses which are arranged in somewhat definite layers. The upper layers of the limestone are the thinner and often of a bluish color. The heavy beds, where long exposed, weather into rather thin

[1] *Geol. Surv. Ohio*, Vol. III, 1878, pp. 615, 616.
[2] *Geol. Surv. Ohio*. 4th Ser., Bull. No. 4, 1906, p. 90, Samples 37-39.

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irregular layers which break into angular blocks and fall to the base of the cliff, forming the usual talus slope. This portion of the formation always shows a crystalline or sub-crystalline structure. It is high in its percentage of calcium carbonate, which ranges from eighty-one and fourteen hundredths to ninety-three and twenty-eight hundredths per cent. in samples taken from Marble Cliff quarries.[1] While all layers seem to contain abundant fossils, many are literally crowded with the remains of the various species which swarmed in the waters of this warm Devonian sea.

The base of the Columbus limestone rests upon the Monroe formation; this contact being that between the two great systems, the Silurian and the Devonian. There is thus a great time gap or unconformity, between these two formations, which is strikingly illustrated by the decided change in character and abundance of animal remains. In some localities the lowest layers of the Columbus contain an abundant fauna which in many respects resembles that of the upper part of the same formation, but where these lower layers have been observed in Franklin, Delaware and Union counties, a basal conglomerate is found which consists of large and small water-worn pebbles of the underlying formation embedded in a matrix of Columbus limestone. Where this conglomerate is developed few fossils are found; probably because the organic remains, which existed in these localities at the time the layers in question were being deposited, were ground to a shapeless mud by the continuous action of the waves among the pebbles of a rocky coast. This conglomerate was formerly supposed to represent the Oriskany sandstone of New York, and was so mapped by the geologists who made the first county reports, as well as by Newberry himself;[2] but, since this basal conglomerate is not continuous and has not been proven to be Oriskany, it has been customary of later years, and perhaps wisely, to drop the Oriskany sandstone from the Ohio scale and include these deposits with the Columbus limestone to which they are at least very closely related.

The upper limit of the Columbus is no less interesting since it terminates in the famous "bone-bed" first described by Orton.[3] This layer or bed comprises the upper six or eight inches of the formation, and is frequently made up of an "assemblage of millions on millions of generally imperfect but mostly recognizable organs or fragments of the bony structure of the forms of fish life most characteristic of the Devonian age."[4] These teeth and dermal plates are often in an excellent state of preservation, retaining even their original luster. Contrary to what has usually been supposed, this limiting layer of the formation may be traced

[1] *Geol. Surv. Ohio*, Vol. III, 1878, p. 617; also *Geol. Surv. Ohio*, 4th Ser., Bull. No. 4, 1906, pp. 64, 65.
[2] *Geol. Surv. Ohio*, Rept. Prog. for 1869, (1870), Map opp. title page.
[3] *Geog. Surv. Ohio*, Vol. III, 1878, pp. 610, 611 and 628.
[4] Newberry, J. S., *Mong. U. S. Geol. Surv.*, Vol. XVI, 1889, p. 30.

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northward to Sandusky, where it has proved of invaluable assistance in determining the line of division between the Columbus and Delaware limestones.[1]

The Delaware limestone extends from the "bone-bed" upward through a thickness of about thirty-six feet to its contact with the Olentangy shale. It is extremely variable in its appearance, consisting sometimes of thin shaly layers, beds of chert and fairly massive limestone and again almost entirely of rather massive limestone with very little chert and no shale. Usually it has a deep blue to slate-color, which becomes brown on weathering. The chert, which it contains, is mostly black and non-fossiliferous, but, in sections where little occurs, it is often a light bluish-white or even pure white and somewhat fossiliferous. In general the Delaware limestone is less fossiliferous than the upper part of the Columbus, but its fauna is by no means small, and frequently layers are found which are very fossiliferous. The variable chemical composition of this formation is easily seen by a reference to the analyses of various samples collected at different localities.[2]

The Olentangy shale extends from the top of the Delaware limestone to the base of the Ohio shale, a vertical distance of about thirty-one feet in Franklin county. It has been found to be almost invariably present in the central strip from Sandusky southward. In Pickaway county, where the Devonian limestones last appear, this shale occurs, and from thence southward overlaps on the older rocks until at Bainbridge it rests on Niagaran limestones. The Devonian shales cross the Ohio River at Vanceburg, and even near Fox Springs, Fleming county, Kentucky, the basal shale has the appearance of the Olentangy.[3] As seen in the river bank at Delaware, the Olentangy is a soft bluish shale, with numerous disc-like argillaceous limestone concretions near the basal portion, and layers of impure limestone in the middle and upper portions. (See Plate V). The formation contains few fossils in central Ohio, but becomes quite fossiliferous in the Sandusky region, where it includes a limestone member, at the top, which has been known as the Prout limestone. The thickness of the formation is there also greatly increased.

[1] *Jour. Geol.*, Vol. XIII, No. 5, 1905, p. 435.
[2] *Rept. Geol. Surv. Ohio*, Vol. III, 1878, pp. 617, 618; also *Geol. Surv. Ohio*, 4th Ser., Bull. No. 4, 1906, pp. 61, 65, 95, 125, etc.
[3] Morse, W. C., Private communication, 1908.

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CHAPTER II.

DISCUSSION OF SECTIONS AND FAUNAS.

GENERAL SECTION FOR CENTRAL OHIO.

During the progress of the field work in connection with the development of this subject, all measurements, where possible, were made from the two well fixed boundaries of the Columbus limestone, its contact with the Monroe formation and the "bone-bed." Other persistent and apparently fixed characteristics have been observed. Of these the most important are the horizons at which certain faunas occur and the zonal character of the chert beds. A comparison of various sections from central Ohio, after the identification of the species from the collection of each, shows that certain groups of species usually occur in the same relation to each other and at relatively the same positions in the section. This has led to the arrangement of a general section, to which others may be referred, in which the formations are divided into zones, each of which has some faunal or lithological feature or both, which seems to be characteristic of it. This section does not agree in all of its particulars with that found farther north, and yet there are some things in common.

Of course it is not to be supposed that the lines of division between these zones are definite and sharp, although sometimes that is the case, nor that a form persistently occurring in one may not occur in another. *Hadrophyllum d'orbignyi*, which has been found constant enough in the Delaware limestone to be considered as forming a thin zone, also occurs in the "bone-bed" and slabs of limestone from this last named horizon, have been collected near Columbus, in which this Coral is imbedded in great numbers, but it cannot be traced from section to section over an extended area as it can in its later occurrence. *Tentaculites scalariformis* may be found throughout the whole of the Delaware limestone and sometimes in great numbers, as far down into the Columbus limestone as the middle of the chert zone, but its greatest abundance has been found some eight or ten feet above the base of the Delaware. *Spirifer acuminatus* occurs throughout a small range in the southern part of the central area, and seems to have essentially the same zone in Indiana,[1] but at Sandusky it is found in abundance at several horizons below that

[1] *Bull. Am. Pal. No. 12*, 1899, p. 110; also 25th Ann. Rept. *Dept. Geol. and Nat. Res. of Ind.*, 1900, p. 538.

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mentioned in the general section. *Spirifer gregarius* also has an extensive range through the Columbus, but what is called the "*Sp. gregarius* zone" is found to contain this fossil in large numbers, sometimes fairly crowding each other in the layers. And so others might be pointed out, but where the species is mentioned as characteristic of a zone, it is believed to occur in its greatest abundance, and as a rule these divisions are quite easily recognized.

GENERAL SECTION OF THE MIDDLE DEVONIAN OF CENTRAL OHIO.

Ohio shale.

Olentangy shale.

Feet.

Soft blue shale with layers of impure blue limestone. Fossils rare in central Ohio but becoming plentiful in the north, where several distinct zones may be distinguished 31

Delaware limestone.

(Zone M) Grayish or bluish brown limestone in layers of about six inches and containing some fossiliferous chert. This is the horizon which Winchell called "Tully limestone" and which Newberry conceded to contain a Hamilton fauna. Average thickness.... 10

Common fauna of this zone.

Aulopora conferta Winchell
Aviculopecten princeps (Conrad)
Nyassa arguta Hall
Ambocœlia umbonata (Conrad)
Atrypa reticularis (Linnaeus)
Camarotœchia prolifica (Hall)
Chonetes mucronatus (Hall)
Pholidostrophia iowaensis (Owen)
Rhipidomella vanuxemi Hall
Stropheodonta concava Hall
Stropheodonta perplana (Conrad)
Stropheodonta demissa (Conrad)

Feet.

(Zone L) Granular grayish brown limestone, frequently made up to a large extent of the globular Coral, *Hadrophyllum d'orbignyi*. It also contains many Brachiopods and occasionally abundant fish teeth. Iron pyrites often replaces the substance of the fossils. Average thickness..... ¼

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Common fauna of this zone.

Hadrophyllum d'orbignyi Edwards and Haime
Cystodictya gilberti (Meek)
Fistulipora vesiculata (Hall and Simpson)
Trematella arborea (?) (Hall)
Atrypa reticularis (Linnaeus)
Camarotœchia tethys (Billings)
Chonetes mucronatus Hall
Chonostrophia reversa (Whitfield)
Delthyris consobrina (d'Orbigny)
Eunella lincklæni Hall
Pholidostrophia iowaensis (Owen)
Rhipidomella vanuxemi Hall
Spirifer audaculus mucronatus Hall
Spirifer macrus Hall
Stropheodonta concava Hall
Stropheodonta demissa (Conrad)
Stropheodonta hemispherica Hall
Stropheodonta perplana (Conrad)
Conocardium sp.

Feet.

(Zone K) Frequently containing much black chert and Occasionally fairly massive layers of blue or brown limestone alternating with thin cherty layers. At the base it is often more or less contorted. *Grammysia bisulcata* is a common fossil. Average thickness.... 11

Common fauna of this zone.

Cystodictya gilberti (Meek)
Camarotœchia billingsi Hall
Camarotœchia tethys (Billings)
Chonetes mucronatus Hall
Leptæna rhomboidalis (Wilckens)
Rhipidomella vanuxemi Hall
Spirifer audaculus macronotus Hall
Stropheodonta demissa (Conrad)
Glyptodesma erectum (Conrad)
Grammysia bisulcata (Conrad)
Grammysia arcuata Whitfield

Feet.

(Zone J) Usually a massive blue limestone with some thin or shaly layers and occasionally much black chert. It contains a great abundance of *Tentaculites scalariformis.* Average thickness..... 9

Common fauna of this zone.

Fenestella parallela (?) Hall
Ambocœlia umbonata (Conrad)
Chonetes mucronatus Hall

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Chonetes scitulus Hall
Chonostrophia reversa (Whitfield)
Delthyris consobrina (d'Orbigny)
Leiorhynchus limitare (Vanuxemi)
Leptæna rhomboidalis (Wilckens)
Lingula ligea Hall
Orbiculoidea lodiensis (Vanuxem)
Rhipidomella vanuxemi Hall
Spirifer macrus Hall
Stropheodonta demissa (Conrad)
Glyptodesma erectum (Conrad)
Platyceras erectum Hall
Tentaculites scalariformis Hall

Feet.

(Zone I) Brown to bluish shale or thin-bedded shaly limestone with some black chert. To the north it becomes massive, but seems to retain its distinctive fauna of *Leiorhynchus limitare, Lingula manni, Orbiculoidea lodiensis,* etc. This is Whitfield's Marcellus shale. Average thickness..... 6

Common fauna of this zone. In the shaly layers are found:

Chonostrophia reversa (Whitfield)
Delthyris consobrina (d'Orbigny)
Leiorhynchus limitare (Vanuxem)
Leptaena rhomboidalis (Wilckens)
Lingula manni Hall
Martinia maia (Billings)
Orbiculoidea lodiensis (Vanuxem)
Orbiculoidea minuta (Hall)
Tentaculites scalariformis Hall

And in addition to this fauna, as these layers pass into thick bedded limestone to the north, may be found:

Cystodictya gilberti (Meek)
Orthopora regularis Hall
Camarotœchia billingsi Hall
Camarotœchia tethys (Billings)
Chonetes mucronatus Hall
Productella spinulicosta Hall
Spirifer macrus Hall.
Stropheodonta concava Hall
Macrodon sp.
Paracyclas elliptica Hall
Sphenotus cuneatus (Conrad)
Platyceras erectum (Hall)

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Columbus limestone.

Feet.

(Zone H) Thin bedded to massive bluish gray limestone. At the top it contains the "bone-bed," which has a thickness varying from several inches to a foot or more and is made up to a greater or less extent of the teeth, bones and dermal plates of fish. It also contains some fossiliferous gray chert which often occurs in layers. The zone contains many fossils, among which are especially to be mentioned, *Spirifer acuminatus, Nucleocrinus verneuili, Spirifer duodenarius, Paracyclas elliptica, Diphyphyllum verneuilanum.* Average thickness..... 10

Common fauna of this zone.

Cyathophyllum robustum Hall
Diphyphyllum verneuilanum (Edwards and Haime)
Favosites emmonsi Rominger
Favosites hemisphericus (Troost)
Codaster pyramidatus Shumard
Nucleocrinus verneuili (Troost)
Cystodictya gilberti (Meek)
Atrypa reticularis (Linnaeus)
Atrypa spinosa Hall
Chonetes mucronatus Hall
Camarotœchia tethys (Billings)
Eunella lincklæni Hall
Leptæna rhomboidalis (Wilckens)
Pentamerella arata (Conrad)
Pholidostrophia iowaensis (Owen)
Schizophoria propinque Hall
Spirifer acuminatus (Conrad)
Spirifer duodenarius (Hall)
Spirifer macrus Hall
Stropheodonta concava Hall
Stropheodonta hemispherica Hall
Stropheodonta inæquistriata (Conrad)
Stropheodonta perplana (Conrad)
Aviculopecten cleon Hall
Aviculopecten princeps (Conrad)
Loxonema pexatum Hall
Platyceras dumosum Conrad
Platyceras multispinosum Meek
Tentaculites scalariformis Hall
Chasmops calypso Hall
Odontocephalus bifidus (?) Hall
Phacops cristata Hall

Feet.

(Zone G) Massive gray limestone in beds from eight inches to three feet in thickness. Very fossiliferous and characterized by the occurrence in it of such large Cephalopods as *Gyroceras cyclops, Gyroceras Columbiense*, etc. Average thickness..... 22

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Common fauna of this zone.

Calcisphæra robusta Williamson
Stromatopora ponderosa Nicholson
Zaphrentis cornicula (Edwards and Haime)
Atrypa reticularis (Linnæus)
Atrypa spinosa Hall
Chonetes mucronatus Hall
Delthyris raricosta Conrad
Spirifer gregarius Clapp
Spirifer macrus Hall
Stropheodonta hemispherica Hall
Stropheodonta inæquistriata (Conrad)
Stropheodonta perplana (Conrad)
Conocardium cuneus (Conrad)
Limoptera pauperata (?) Hall
Paracylas elliptica Hall
Callonema lichas (Hall)
Euomphalus decewi Billings
Loxonema pexatum Hall
Pleurotomaria lucina Hall
Turbo shumardi (Verneuil)
Gyroceras columbiense Whitfield
Gyroceras cyclops Hall
Coronura diurus (Green)

Feet.

(Zone F) Massive gray limestone containing numerous fossils, but *Spirifer gregarius* exceedingly abundant, and usually referred to as the *Sp. gregarius* zone. Average thickness 5

Common fauna of this zone.

Zaphrentis cornicula (Edwards and Haime)
Zaphrentis gigantea Rafinesque
Atrypa reticularis (Linnæus)
Atrypa spinosa Hall
Chonetes mucronatus Hall
Eunella lincklæni Hall
Nucleospira concinna Hall
Pholidostrophia iowaensis (Owen)
Spirifer divaricatus Hall
Spirifer gregarius Clapp
Spirifer macrus Hall
Stropheodonta hemispherica Hall
Stropheodonta inæquistriata (Conrad)
Stropheodonta perplana (Conrad)
Conocardium cuneus (Conrad)
Modimorpha concentrica (Conrad)
Paracyclas elliptica Hall
Bellerophon pelops Hall
Callonema lichas (Hall)
Murchisonia desiderata var. Hall
Platyceras dumosum Conrad
Coleolus crenatocinctus Hall
Phacops cristata Hall

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Feet.

(Zone E) Massive gray limestone with an abundant fauna, but *Spirifer macrothyris* and *Strophonella ampla* are especially abundant. Average thickness..... 20

Common fauna of this zone.

Stromatopora ponderosa Nicholson
Favosites emmonsi Rominger
Favosites hemisphericus (Troost)
Syringopora tabulata Edwards and Haime
Zaphrentis gigantea Rafinesque
Athyris vittata indianaensis n. var.
Atrypa reticularis (Linnæus)
Chonetes mucronatus Hall
Delthyris raricosta Conrad
Eunella lincklæni Hall
Leptæna rhomboidalis (Wilckens)
Meristella nasuta (Conrad)
Nucleospira concinna Hall
Productella spinulicosta Hall
Schizophoria propinque Hall
Spirifer divaricatus Hall
Spirifer gregarius Clapp
Spirifer macrothyris Hall
Spirifer macrus Hall
Spirifer manni Hall
Stropheodonta hemispherica Hall
Stropheodonta inæquistriata (Conrad)
Stropheodonta patersoni Hall
Stropheodonta perplana (Conrad)
Strophonella ampla Hall
Conocardium cuneus (Conrad)
Modiomorpha concentrica (Conrad)
Mytilarca percarinata Whitfield
Paracyclas elliptica Hall
Plethomytilus ponderosa Hall
Bellerophon pelops Hall
Callonema lichas Hall
Euomphalus decewi Billings
Loxonema pexatum Hall
Palæotrochus kearneyi Hall
Platyceras attenuatum Hall
Platyceras carinatum Hall
Platyceras dumosum (?) Conrad
Pleurotomaria lucina Hall
Turbo shumardi Verneuil
Coleolus crenatocinctus Hall
Tentaculites scalariformis Hall
Gyroceratites ohioensis Meek
Orthoceras ohioense Meek
Orthoceras thoas Hall
Coronura diurus (Green)
Phacops cristata Hall

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Feet.

(Zone D) Layers of gray chert alternating with layers of a sub-crystalline gray or brown limestone. Chert hard to chalky and very fossiliferous, containing a great variety of Gastropods and many Brachiopods, Pelecypods, Corals and Bryozoa. The fossils usually have their exterior markings excellently preserved. This is the chert or Gastropod zone. Average thickness..... 8

Common fauna of this zone.

Stromatopora ponderosa Nicholson
Syringostroma columnaris Nicholson
Fayosites emmonsi Rominger
Favosites hemisphericus (Troost)
Zaphrentis sp.
Coscinium striatum Hall and Simpson
Fenestella parallela Hall
Lichenalia sp.
Nemataxis fibrosus Hall
Polypora celsipora (Hall)
Polypora flabelliformis (?) (Hall)
Polypora hexagonalis (Hall)
Polypora robusta (Hall)
Prismopora triquetra Hall
Semicoscinium bi-imbricata (Hall)
Stictopora sp.
Unitrypa tegulata (Hall)
Atrypa reticularis (Linnæus)
Atrypa spinosa (?) Hall
Camarotœchia tethys (Billings)
Chonetes mucronatus Hall
Crania sp.
Eunella lincklæni Hall
Meristella nasuta (Conrad)
Nucleospira concinna Hall
Pholidostrophia iowaensis (Owen)
Productella spinulicosta Hall
Rhipidomella vanuxemi Hall
Spirifer divaricatus Hall
Spirifer macrus Hall
Spirifer manni Hall
Stropheodonta demissa (?) (Conrad)
Stropheodonta hemispherica Hall
Stropheodonta inæquistriata (Conrad)
Stropheodonta perplana (Conrad)
Strophonella ampla Hall
Conocardium cuneus (Conrad)
Conocardium cuneus attenuate Conrad
Conocardium cuneus trigonale Hall
Goniophora sp.
Grammysia subarcuata (?) Hall

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Modiomorpha concentrica (Conrad)
Mytilarca percarinata Whitfield
Nucula niotica Hall and Whitfield
Nucula sp.
Paracyclas ohioensis Meek
Plethomytilus ponderosa Hall
Schizodus contractus Hall
Schizodus tumidus Hall
Bellerophon hyalina Hall
Bellerophon newberryi Meek
Bellerophon pelops Hall
Bellerophon sp.
Callonema bellatulum (Hall)
Callonema clarki Nettelroth
Callonema lichas (Hall)
Cyclonema crenulatum Meek
Dentalium martini Whitfield
Isonema depressum Meek and Worthen
Isonema humile Meek
Loxonema læviusculum Hall
Loxonema pexatum Hall
Loxonema robustum Hall
Loxonema sp.
Macrochilina hebe (?) (Hall)
Macrochilina macrostoma (Hall)
Macrochilina prisca (Whitfield)
Murchisonia desiderata Hall
Murchisonia maia Hall
Naticopsis æquistriata Meek
Naticopsis comperta Hall
Naticopsis lævis Meek
Orthonema newberryi Meek
Platyceras bucculentum Hall
Pleurotomaria adjutor Hall
Pleurotomaria hyphantes Meek
Pleurotomaria lucina Hall
Pleurotomaria plena Hall
Pleurotomaria sp.
Pseudophorus antiquus Meek
Strophostylas varians Hall
Coleolus crenatocinctus Hall
Gyroceras columbiense Whitfield
Orthoceras cretaceum Whitfield
Orthoceras nuntium Hall
Orthoceras ohioense Hall
Orthoceras sirpus Hall
Orthoceras thoas Hall
Phacops cristata Hall

	Feet.
(Zone C) Brown limestone, quite massive, with numerous Corals imbedded in it. At places it becomes a true fossil Coral reef. Usually called the Coral zone. Average thickness.....	4

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Common fauna of this zone.

Stromatopora ponderosa Nicholson
Cladopora pulchra Rominger
Cladopora robusta Rominger
Diphyphyllum simcoense (Billings)
Diphyphyllum strictum (Edwards and Haime)
Favosites emmonsi Rominger
Favosites goldfussi d'Orbigny
Favosites hemisphericus (Troost)
Syringopora tabulata Edwards and Haime
Zaphrentis gigantea Rafinesque
Atrypa reticularis (Linnæus)
Camarotœchia tethys (Billings)
Chonetes mucronatus Hall
Eunella lincklæni Hall
Meristella rostrata (?) Hall
Reticularia fimbriata (Conrad)
Spirifer macrothyris Hall
Spirifer macrus Hall
Stropheodonta hemispherica Hall
Stropheodonta inæquistriata (Conrad)
Actinopteria sp.
Aviculopecten cleon Hall
Paracyclas elliptica (?) Hall

Feet.

(Zone B) Brown limestone, exceedingly massive, showing but few irregular bedding planes, and at places appearing as a solid wall without bedding planes. It contains much bituminous matter, has a saccharoidal appearance, and often shows a slightly banded structure. The fresh surface of the rock sometimes glistens with cleavage faces of calcite and frequently contains pockets of the crystals. It also contains more or less chert scattered through the upper part. Fossils are usually rare and poorly preserved. Average thickness 35

Common fauna of this zone.

Cladopora pulchra Rominger
Diphyphyllum simcoense (Billings)
Syringopora tabulata Edwards and Haime
Zaphrentis gigantea Rafinesque
Fenestella erectipora (?) Hall
Fenestella sp.
Fistulipora substellata (?) Hall
Nemataxis fibrosus Hall
Camarotœchia billingsi Hall
Meristella nasuta (Conrad)
Spirifer macrus Hall
Stropheodonta demissa (?) (Conrad)
Stropheodonta hemispherica Hall
Strophonella ampla Hall
Conocardium cuneus (Conrad)
Pleurotomaria sp.

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	Feet.
(Zone A) Usually a conglomerate composed of water-worn pebbles of Monroe limestone imbedded in a matrix of brown Columbus limestone. Fragments of fossils are occasionally found, but northward the conglomerate ceases and the zone becomes very fossiliferous. Average thickness.....	1

Monroe limestone.

SECTIONS AND FAUNAS OF THE CENTRAL DISTRICT.

The rock sections of the southern part of the state show only the upper formation, the Olentangy shale, of the Middle Devonian, and even that is sometimes wanting. In the vicinity of Buena Vista, Scioto county, J. E. Hyde found a considerable thickness of soft gray shales alternating with black shales forming the base of the section, although the underlying limestone was not exposed at the place observed. At Mineral Springs station, Adams county, however, the underlying limestone was found, and above it occurs "about six inches of black fissile shale" which is succeeded by a slight covered interval, and then follows "five feet (estimated) of very light gray, almost white, clay shale very like the Olentangy;"[1] and this is succeeded by black shales with another gray band higher up. Perhaps this is the Olentangy shale, but at Kinkead Springs, one mile west of Latham, Pike county, the black shale extends down to the limestone, and is firmly welded to it.

Bainbridge.—In the gulleys leading down from Benner's Hill,[2] on the east side of Buckskin Run, a tributary to Paint Creek and about two miles north of Bainbridge, Ross county, are excellent sections from the Silurian well up into the Mississippian. The base of the section is formed by the Niagaran and Cayugan limestones above which follows immediately about thirty feet of the Olentangy shale. Near the bottom of this blue shale are two layers of purple shale, marked with trails of the light blue, as in the sections of central Ohio. There are also a few layers of brown shale, in which an occasional specimen of *Lingula* occurs, interstratified with the blue layers, and near the top of the formation the flat disc-like blue limestone concretions, so characteristic of the formation at the type locality, are to be found. Above the Olentangy shale comes the regular central Ohio section up to and including the Cuyahoga formation. The notable feature here, as at all of the other Ohio localities to the south, is the absence of the Middle Devonian limestones. This indicates a transgression of the sea along the southeastern portion of the

[1] Hyde, J. E., letter of September 24th, 1909.

[2] See Orton, Edward, *Geol. Surv. Ohio*, Vol. II, 1874, pp. 645, 646; also Prosser, Charles S., *Jour. Geol.*, Vol. X, 1902, pp. 278-282.

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Cincinnati Island from Deer Creek, Pickaway county, where the last of the limestones outcrop, southward into Kentucky, during Olentangy time.

Deer Creek.—Along Deer Creek in Pickaway county there are several Devonian limestone outcrops, from which the stone was once quarried and burned for lime. These old lime-kilns have long since tumbled down, and even the quarries are more or less covered by the caving of the soil and mantle rock. A representative of these[1] may be found on the farm belonging to Mr. Thomas, and lying on the north side of the creek five and one-half miles northwest of Williamsport and four miles north of Atlanta. The old kiln, where the following section may be found, was located in a ravine entering Deer Creek from the north about one-half mile east of the mill.

Columbus limestone.

		Ft.	In.
3.	Crystalline gray limestone, quite fossiliferous and partly covered	5	4
2.	Conglomerate made up of water-lime pebbles imbedded in Columbus limestone, all well exposed	1	0

Monroe limestone.

1.	Compact banded drab limestone	3	0

From number three of the above section, the following species were collected:

Favosites emmonsi Rominger
Favosites hemisphericus (Troost)
Meristella nasuta (Conrad)
Stropheodonta demissa (Conrad)
Stropheodonta hemispherica Hall
Conocardium cuneus (Conrad)

On the south side of the creek opposite the above section are other outcrops. A well dug on the hill just above is said to have struck limestone at a depth of fifty-six feet. Immediately above the limestone the man who dug the well reports the occurrence of a "blue soapstone clay twenty feet deep, which is in distinct layers, has no grit and could be spaded out like clay"—probably the Olentangy shale.

The presence of the basal conglomerate indicates shore conditions at the beginning of the Devonian, but whether or not the limestones

[1]See also Bownocker, J. A., *Bull. Sci., Lab. Den. Univ.*, Vol. XI, 1898, pp. 17, 18.

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have appreciably thinned out at this point is somewhat uncertain. The section just given seems to indicate the disappearance of the lower or brown dolomitic portion of the Columbus limestone, and the probable presence of the Olentangy shale at such a short interval above the Monroe formation, points to a lessening of the distance between these two formations.

Andrews states that the Devonian limestones occur "in the northwestern corner of Ross county,"[1] but an examination of the outcrops of that locality failed to reveal anything but Monroe limestone.

Harrisburg.—This town lies fifteen miles southwest of Columbus, and at the point where the Big Darby crosses the Franklin-Pickaway county line. The creek flows over rock above the lower highway bridge, and indeed the whole of this part of the valley is but a few feet above the rock, as is shown by the holes dug in setting telephone poles and by the numerous small outcrops along the road from Morgan. The most important exposed section is west of the creek at the old lime-kiln by the flowing wells. Here in a small quarry at the foot of the hills, the rock has been removed to a depth of perhaps ten feet, and its character excellently shown although the section itself is rather unsatisfactory. The limestone has a gray color, is fairly massive and abounds in fossils. This is especially true of some layers which are made up almost entirely of the remains of Brachiopods.[2] In the course of several hours the following species were collected from the loose material around the kiln:

Cystiphyllum vesiculosum Goldfuss
Favosites emmonsi Rominger
Syringopora tabulata Edwards and Haime
Zaphrentis cornicula Edwards and Haime
Atrypa reticularis (Linnæus)
Chonetes mucronatus Hall
Camarotœchia billingsi Hall
Meristella nasuta (Conrad)
Rhipidomella cleobis Hall
Rhipidomella vanuxemi Hall
Schizophoria propinque Hall
Spirifer divaricatus Hall
Spirifer gregarius Clapp
Spirifer macrothyris Hall
Spirifer macrus Hall
Stropheodonta concava Hall
Stropheodonta demissa (Conrad)
Stropheodonta inæquiradiata (Conrad)
Strophonella ampla Hall
Conocardium cuneus (Conrad)
Modiomorpha concentrica (Conrad)

[1] *Geol. Surv. Ohio*, Vol. II, pt. 1, 1874, p. 592.
[2] See *Bull. Sci. Lab. Den. Univ.*, Vol. XI, 1898, p. 20.

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Pterinea fiabellum (Conrad)
Schizodus tumidus Hall
Bellerophon pelops Hall
Callomena lichas (Hall)
Euomphalus decewi Billings
Loxonema pexatum Hall
Loxonema sp.
Platyceras dumosum Conrad
Pleurotomaria lucina Hall
Turbo shumardi Verneuil
Tentaculites scalariformis Hall
Orthoceras sp.
Coronura diurus (Green)
Odontocephalus bifidus Hall
Phacops cristata Hall

It seems quite probable that this outcrop lies from forty to fifty feet below the "bone-bed" or top of the Columbus limestone, since the above fauna is that of Zone E in the general section.

Georgesville.—In the vicinity of Georgesville at the junction of the Big and Little Darby Creeks, about seven miles northwest of Harrisburg, and on the Big Four Railroad thirteen miles southwest of Columbus, the base of the Columbus limestone is shown with the underlying Monroe formation. Perhaps the best exposure is the cliff about a half-mile above the dam across the Little Darby and where the creek makes a sharp turn from a southerly to an easterly direction on Mr. E. N. Coberly's farm. Here the following section may be seen.

Columbus limestone.

	Ft.	In.
Brownish gray crystalline limestone, honeycombed, containing crystals of calcite, overhanging the formation below and most of the exposed surfaces stained red by iron oxides. A few fragments of fossils seen.....	14	5

Monroe limestone.

Thin bedded drab limestone, having a laminated structure and very compact. Partly covered near the creek.....	18	6

The upper layers of the Monroe limestone show some signs of weathering, but there seems to be no conglomerate developed in the base of the Columbus limestone at this particular place, although on the west

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bank of the Big Darby, two miles above Georgesville, just north of the cottages on the A., C. and M. Eckles farm, it is nicely shown in an old quarry, of which the following is a section.

Columbus limestone.

		Ft.	In.
5.	Massive brown limestone containing a few Corals of the genus *Favosites;* and cavities, some of which are quite large, filled with crystals of calcite.....	10	4
4.	Conglomerate composed of large rounded pebbles of compact drab limestone imbedded in brown limestone.....	0	8
3.	Brownish limestone containing a few small pebbles	0	7

Monroe limestone.

2.	Massive drab limestone containing *Leperditia alta*	1	10
1.	Partly covered with blocks thrown from the quarry, to creek level.....	1	8

The following species were found in No. 5 of the above section:

Favosites emmonsi Rominger
Favosites goldfussi d'Orbigny
Favosites hemisphericus (Troost)
Favosites maximus (Troost)
Favosites sp.
Zaphrentis gigantea Rafinesque
Zaphrentis prolifica Billings
Zaphrentis sp.
Fenestella sp.
Atrypa spinosa Hall
Stropheodonta demissa (Conrad)
Stropheodonta hemispherica Hall

The base of the Columbus limestone is again shown on the east bank of the Little Darby, three and one-half miles above Georgesville and near the old lime-kiln just below Mr. Charles Roberts' house, as well as in an old quarry in the field northeast of his barn. The section is mostly in the Monroe formation, but the conglomerate at the base of the Devonian may be seen near the top. It presents no new features and possesses interest solely because of the important contact which is here exposed. No fossils were seen in this locality.

The banks of the Scioto and its tributaries from Columbus northward to near Warrensburg, furnish many and interesting sections. No

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single outcrop gives the whole of the Columbus limestone, yet within a very few miles both contacts may be seen, and by combining the sections at these places a fair idea of the formation may be obtained. However, it is not a safe conclusion to assume that the true thickness of the Columbus limestone is thus obtained, even though zones which are considered equivalent are found at both places.

Columbus.—Just outside of the city limits, and near the State Hospital for the Insane, lie the State Quarries.[1] The importance of this section has deteriorated much, within the past score of years, from the fact that the quarries have been practically abandoned, and are thus in a state of ruin. But as many fine collections have been obtained and some new species described from this historic ground, it is safe to assume that a geological interest will be attached to it for years to come. The following section was measured just south of the Big Four Railroad tracks, where a fair section may still be seen.

Delaware limestone.

		Ft.	In.
10.	Zone I. Thin shaly brown limestone alternating with irregular layers of black chert	3	0

Columbus limestone.

9.	Zone H. Massive fossiliferous gray limestone containing the "bone-bed" at the top	1	0
8.	Fossiliferous grayish white chert.....	0	3
7.	Massive Crinoidal gray limestone.....	3	0
6.	Fossiliferous light gray chert.....	0	3
5.	Massive gray limestone.....	2	0
4.	Fossiliferous light gray chert.....	0	2
3.	Massive gray limestone.....	1	4
2.	"Smooth layer".....	..	..
1.	Zone G. Massive gray limestone, very fossiliferous, especially containing a large number of cup Corals. No chert.....	12	0

The term "smooth layer" or "smooth rock," number two of the above section, was probably introduced by Orton.[2] It has the appearance of a plane, sometimes undulating, along which lateral motion has occurred. The rock both above and below the plane is smoothed and fossils occurring in its path have been sheared off. It can be traced northward beyond Dublin, still retaining its distance of eight to ten feet below the "bone-bed."

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[1] *Geol. Surv. Ohio*, Vol. III, 1878, pp. 612-614.
[2] Orton, Edward, *Geol. Surv. Ohio*, Vol. III, 1878, pp. 608-610.

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The following small collection of species was made from the upper part (Zone H) of the Columbus limestone:

Diphyphyllum verneuilanum (Edwards and Haime)
Zaphrentis cornicula Edwards and Haime
Zaphrentis gigantea Rafinesque
Zaphrentis wortheni Nicholson
Codaster pyramidatus Shumard
Nucleocrinus verneuili (Troost)
Fenestella parallela Hall
Fenestella sp.
Polypora celsipora minima (?) Hall
Atrypa reticularis (Linnæus)
Chonetes mucronatus Hall
Cyrtina hamiltonensis Hall
Eunella lincklæni Hall
Nucleospira concinna Hall
Pholidostrophia iowaensis (Owen)
Reticularia fimbriata (Conrad)
Schizophoria propinque Hall
Spirifer acuminatus Conrad
Spirifer duodenarius (Hall)
Spirifer sp.
Stropheodonta hemispherica Hall
Stropheodonta inæquiradiata Hall
Stropheodonta perplana (Conrad)
Aviculopecten cleon Hall
Platyceras dumosum Conrad
Platyceras multispinosum Meek
Tentaculites scalariformis Hall
Orthoceras sp.
Phacops cristata Hall

Marble Cliff.—On Fifth avenue, three and one-half miles west from High street, is the railway station known as Marble Cliff. In its immediate vicinity there are quite a number of large quarries, with similar sections, but none of them passing through the entire Columbus limestone.

The Smith and Price quarry is the old pit located on the east bank of the Scioto and just above the Pennsylvania Railroad bridge. The contact between the Columbus and Delaware limestones is excellently shown here, as is also the case in the neighboring quarries.

	Ft.	In.
8. Drift	4	0

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Delaware limestone.

		Ft.	In.
7.	Zone J. Thin bedded brown limestone containing several layers of black chert and cherty limestone	9	10
6.	Zone I. Thin shaly brown limestone with layers of chert	4	0
5.	Brown shale alternating with black chert and cherty limestone. The lower seven inches is all shale and very fossiliferous	2	0

Columbus limestone.

4.	Zone H. "Bone bed"	..	..
3.	Gray limestone in eight to twelve-inch layers. It contains a distinct bone bed at the top and some fish remains throughout. Two and one-half feet below the "bone-bed" occurs a three-inch layer of *Diphyphyllum verneuilanum*	9	2
2.	"Smooth layer"	..	..
1.	Zone G. Massive gray limestone in layers from one to three feet in thickness, to the bottom of the quarry	10	4

The following collection of species was obtained largely from the loose material at the north end of the quarry and represents, in the main, Zone I of the Delaware and Zone H of the Columbus.

Delaware limestone.

Chonostrophia reversa (Whitfield)
Leptaena rhomboidalis (Wilckens)
Martinia maia (Billings)
Orbiculoidea lodiensis (Vanuxem)
Orbiculoidea minuta (Hall)

Columbus limestone.

Diphyphyllum verneuilanum (Edwards and Haime)
Zaphrentis cornicula Edwards and Haime
Atrypa reticularis (Linnæus)
Atrypa spinosa Hall
Delthyris raricosta Conrad
Schizophoria propinque Hall
Spirifer acuminatus (Conrad)
Conocardium cuneus (Conrad)
Limopteria pauperata Hall

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Callonema lichas Hall
Euomphalus decewi Billings
Loxonema pexatum Hall
Platyceras dumosum Conrad

Orton gives a section of the rocks in this quarry, in his Franklin county report,[1] and Bownocker collected his Marble Cliff fauna from this place.[2]

Just across the river and south of the Pennsylvania tracks is the quarry of the Columbus Stone Company, formerly known as the Taylor and Bell quarry. Here the limestone has been removed to a depth of fifty-one feet below the "bone-bed," thus giving an excellent idea of the upper part of the Columbus limestone. The following is a section of the rocks in this quarry:

Delaware limestone.

	Ft.	In.
8. Zone J. Thin bedded bluish-brown limestone with some layers of black chert.....	4	0
7. Zone I. Thin shaly limestone with some chert, becoming a true shale at the base. It shows quite regular oblique joints which extend in two directions.....	6	0

Columbus limestone.

6. Zone H. "Bone-bed"	..	..
5. Bluish-gray limestone in five to twelve-inch beds. It contains also several layers of fossiliferous gray chert and a persistent three-inch layer of *Diphyphyllum verneuilanum* two feet eight inches below the top of the "bone-bed"	9	2
4. "Smooth layer"	..	..
3. Zone G. Massive gray limestone in layers from one to two feet.....	22	10
2. Zone F. Massive gray limestone containing numerous specimens of *Spirifer gregarius*	3	0
1. Zone E. Massive gray limestone in two to three-foot layers to the bottom of the quarry	16	0

The following represents a small collection of the species found at this place:

Delaware limestone.

	Zones.
Martinia maia (Billings).....	I
Orbiculoidea lodiensis (Vanuxem).....	I

[1] *Geol. Surv. Ohio*, Vol. III, 1878, p. 608,
[2] *Bull. Sci. Lab. Den. Univ.*, Vol. XI, 1898, pp. 15, 16.

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The south wall of the Columbus Stone Company's quarry at Marble Cliff. The illustration shows the increasing massiveness from the top downward in the Columbus limestone.

(Photo by R. F. Griggs.)

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Columbus limestone.

Stromatopora ponderosa Nicholson	G
Diphyphyllum verneuilanum (Edwards and Haime)	H
Favosites emmonsi Rominger	E
Favosites hemisphericus (Troost)	E, G
Syringopora tabulata Edwards and Haime	E
Zaphrentis gigantea Rafinesque	E
Fenestella sp.	E
Atrypa reticularis (Linnæus)	E, F, G
Chonetes mucronatus Hall	G
Leptæna rhomboidalis (Wilckens)	H
Schizophoria propinque Hall	E
Spirifer gregarius Clapp	E, F
Spirifer macrothyris Hall	E
Spirifer macrus Hall	G
Stropheodonta hemispherica Hall	E, F, G, H
Stropheodonta perplana (Conrad)	G
Strophonella ampla Hall	E
Aviculopecten princeps (Conrad)	H
Conocardium cuneus (Conrad)	E, F
Paracyclas elliptica Hall	G
Euomphalus decewi Billings	G
Loxonema pexatum Hall	E
Platyceras dumosum Conrad	H
Pleurotomaria lucina Hall	E, G
Phacops cristata Hall	H

The rock of the Columbus limestone exposed in this quarry shows its usual even bedding (See Plate I). These bedding planes aid materially in quarrying, the more prominent ones being used as benches. The rock also shows many oblique joints, some of which have been much widened by solution and the sides covered with crystals of calcite or a deposit of travertine. The bottom of the quarry is very near the top of the chert zone. At the west end some of the lowest blasts in the bottom of the quarry have torn up fragments of rock carrying gray chert, which has a Gastropod fauna identical with that of Zone D of the general section. The lower part of this quarry is also interesting from the fact that it has a fauna similar to and approaching in abundance of species that of Harrisburg; in fact, there can be no doubt but that the horizons are the same. Many large specimens of *Favosites emmonsi* and *Syringopora tabulata* project from the bottom course and much organic matter in the form of petroleum is included within the cavities of the fossils of this horizon.

The Casparis quarry is the largest of the Marble Cliff group. It is located about a half-mile up the river from the Pennsylvania station, and occupies the banks on both sides of the Scioto. However, the section,

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except that of the Delaware limestone, is not so great as at the preceding place. The following section was measured on the east side of the river:

Delaware limestone.

		Ft.	In.
12.	Zone K. Rather thin bedded bluish brown limestone containing some chert in the upper part and all much weathered.....	5	0
11.	Zone J. Thin bedded bluish limestone containing a large amount of black chert in layers	5	10
10.	Massive bluish limestone with much black chert intermixed. The upper part is often more or less concretionary in appearance.....	3	8
9.	Zone I. Shaly and rather thick layers of bluish brown limestone containing much black chert	5	0
8.	Soft thin bedded grayish brown shale with some chert.....	0	6

Columbus limestone.

7.	Zone H. "Bone bed," well defined.....	..	..
6.	Bluish gray limestone in six to eight-inch beds and containing three horizons of fossiliferous white chert. All quite fossiliferous	9	4
5.	"Smooth layer," a similar layer occurring eight inches above, is often ripple or wave marked	..	..
4.	Zone G. Very fossiliferous gray limestone, rather thin bedded. The weathered surface shows numerous Corals.....	8	0
3.	Massive fossiliferous gray limestone. Shows prominent oblique joints running approximately north and south	12	0
2.	Zone F. Massive gray limestone exceedingly full of *Spirifer gregarius*.....	4	6
1.	Zone E. Massive bluish gray limestone containing an abundant fauna. Some petroleum occurs in the rock cavities (bottom of quarry)	2	6

The following fossils are more or less abundant here in the Columbus limestone.

	Zones.
Calcisphæra robusta Williamson.....	G
Aulacophyllum sulcatum (d'Orbigny).....	G
Favosites emmonsi Rominger.....	E

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	Zones.
Favosites hemisphericus (Troost)	F, G
Zaphrentis cornicula Edwards and Haime	G
Zaphrentis gigantea Rafinesque	E, G
Zaphrentis sp.	F
Stromatopora ponderosa Nicholson	G
Cystodictya gilberti (Meek)	G, H
Fenestella sp.	F
Atrypa reticularis (Linnæus)	E, F, G, H
Chonetes mucronatus Hall	G
Cyrtina hamiltonensis Hall	G
Delthyris raricosta Conrad	H
Leptæna rhomboidalis (Wilckens)	G, H
Nucleospira concinna Hall	H
Pentamerella arata (Conrad)	H
Rhipidomella vanuxemi Hall	F, G
Schizophoria propinque Hall	G
Spirifer acuminatus (Conrad)	H
Spirifer divaricatus Hall	G
Spirifer gregarius Clapp	E, F
Spirifer macrothyris Hall	E
Spirifer manni Hall	G
Stropheodonta demissa (Conrad)	E, G
Stropheodonta hemispherica Hall	E, G, H
Stropheodonta patersoni Hall	E, G
Stropheodonta perplana (Conrad)	E, F, G
Strophonella ampla Hall	E
Conocardium cuneus (Conrad)	E
Limopteria pauperata Hall	E, G
Modiomorpha concentrica (Conrad)	G
Mytilarca percarinata Whitfield	G
Paracyclas elliptica Hall	G
Bellerophon pelops Hall	G
Bellerophon sp.	G
Callonema bellatulum (Hall)	G
Euomphalus decewi Billings	G
Loxonema sp.	G
Macrocheilus sp.	G
Platyceras carinatum Hall	G
Platyceras dumosum Conrad	E, H
Platyceras sp.	G
Pleurotomaria lucina Hall	E, G
Pleurotomaria sp.	H
Turbo shumardi Verneuil	G (?)
Coleolus crenatocinctus Hall	F
Gomphoceras eximium Hall	G
Gomphoceras sp.	G
Gyroceras columbiense Whitfield	G
Gyroceras cyclops Hall	G
Gyroceras sp.	G
Orthoceras sp.	G
Phacops rana (Green)	F

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Storage Dam.—A mile and a half north of Marble Cliff, the city of Columbus has constructed a large dam across the Scioto River in the creation of a reservoir for water supply. During the fall of 1905 the whole east bank was uncovered, exposing practically all of the more fossiliferous portion of the Columbus limestone. Prior to the beginning of work on this dam, the city engineering department drilled several test wells, which passed through the Devonian and into the Monroe formation of the Silurian. These wells were drilled with a diamond bit so that the drillings were secured in the form of solid cores, affording thus a means of observing the nature of the rock passed through, as well as the possibility of making an accurate measurement of its thickness.[1] There is thus a continuous section through the entire Columbus limestone, of which nearly two-thirds was actually exposed, while the remaining portion is given by a well record of exceptional value. This section therefore becomes a very important one among those of this formation in Ohio. Unfortunately, however, it is one destined to destruction because the filling of the reservoir has brought the water far up along the bank, and thus covered the greater part of the rock formerly exposed. The actual contact of the Columbus and Delaware limestones is not shown at the dam, but it may be found about a hundred yards to the south in a cut along the highway, and again in the Franklin Stone Company's quarry on the west bank just below the dam, where sixteen feet of the Delaware is exposed.

Columbus limestone.

		Ft.	In.
17.	Zone H. "Bone bed"	..	..
16.	Fairly massive bluish gray limestone	9	6
15.	"Smooth layer"	..	..
14.	Zone G. Even bedded bluish to gray limestone becoming quite massive	20	4
13.	Zone F. Massive bluish gray limestone containing large numbers of *Spirifer gregarius*. The cavities in the rock and the interior of many of the fossils are filled with petroleum	5	0
12.	Zone E. Massive bluish gray limestone containing numerous Corals and Brachiopods	16	0
11.	A layer made up largely of *Favosites emmonsi*	0	6
10.	Massive bluish gray limestone containing a large number of Corals, Brachiopods and some Gastropods	2	5
9.	Zone D. Massive grayish-brown limestone with some gray chert which contains some Brachiopods but few Gastropods	2	6

[1]Griggs, R. F., *Ohio Nat.*, Vol. IV, No. 3, 1904, pp. 67, 68.

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		Ft.	In.
8.	Gray chert alternating with layers of light brown limestone. The lower layer of the chert contains a rich Gastropod fauna	6	4
7.	Light gray limestone containing little or no chert	0	6
6.	Zone C. Coral zone, made up largely of the genera *Favosites, Syringopora* and *Diphyphyllum*. The zone also contains Brachiopods and some chert	3	6
5.	Partly covered to the level of the Scioto River	2	8
4.	Zone B. (From the section of well No. 10.) Gravel and soil to top of rock	2	7
3.	Massive brown limestone	24	8
2.	Thinner bedded brown limestone	7	2
1.	Zone A. Conglomerate	2	4

Monroe Formation.

The following fauna was obtained here:

	Zones.
Calcisphæra robusta Williamson	G
Diphyphyllum archiaci Billings	H
Diphyphyllum simcoense (Billings)	C
Diphyphyllum verneuilanum (Edwards and Haime)	H
Favosites emmonsi Rominger	D
Favosites hemisphericus (Troost)	G
Heliophyllum halli Edwards and Haime	H
Syringopora tabulata Edwards and Haime	E
Zaphrentis cornicula Edwards and Haime	F, G
Zaphrentis gigantea Rafinesque	C
Zaphrentis prolifica Billings	G, H
Nucleocrinus verneuili (Troost)	H
Cystodictya gilberti (Meek)	G, H
Fenestella sp.	G
Monotrypa tenuis (Hall)	F
Atrypa reticularis (Linnæus)	C, D, E, F, G, H
Atrypa spinosa Hall	G, H
Camarotœchia sp.	F
Chonetes mucronatus Hall	C, G, H
Cyrtina hamiltonensis Hall	H
Delthyris raricosta Conrad	G
Leptæna rhomboidalis (Wilckens)	H
Meristella nasuta (Conrad)	E
Nucleospira concinna Hall	H
Reticularia fimbriata (Conrad)	H
Rhipidomella vanuxemi Hall	D
Schizophoria propinque Hall	G, H
Spirifer acuminatus (Conrad)	H
Spirifer duodenarius (Hall)	H
Spirifer gregarius Clapp	E, F

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	Zones.
Spirifer macrothyris Hall	C, D, E
Spirifer manni Hall	D, E, H
Spirifer sp.	H
Stropheodonta demissa (Conrad)	G, H
Stropheodonta perplana (Conrad)	D, E, G, H
Stropheodonta hemispherica Hall	C, G, H
Strophonella ampla Hall	C, D
Aviculopecten sp.	H
Conocardium cuneus (Conrad)	D
Paracyclas elliptica Hall	C, G
Glossites teretis (?) Hall	H
Coleolus crenatocinctus Hall	D
Tentaculites scalariformis Hall	E, H
Bellerophon pelops Hall	D
Euomphalus decewi Billings	E
Loxonema pexatum Hall	D
Loxonema robustum Hall	D, G
Murchisonia maia Hall	D
Platyceras dumosum Conrad	H
Pleurotomaria lucina Hall	D, E, G
Phacops cristata Hall	D, G
Proetus crassimarginatus Hall	F

No. 11 of the above section is the layer which forms the bottom of the larger part of the Columbus Stone Company's quarry. It has been found to be quite persistent, occurring in many of the sections of Delaware county also. The evidence of this section and well record seems to substantiate the one hundred and thirty-eight feet referred to the Columbus and Delaware limestones in the State House well record.[1]

Dublin Pike.—From the Storage dam northward the banks of the Scioto formerly gave a section of the upper portion of the Columbus, which was practically continuous for several miles. Much of this is now covered, although many good sections still remain. The cuts along the Dublin turnpike, which follows the eastern side of the river, afford some excellent exposures of the Delaware limestone. These are of interest because they are among the best that occur south of the described sections, and also because they show some of the persistent characteristics of this formation. Near the north end of the new portion of the pike and a mile above Fishinger's bridge is perhaps the best section.

Delaware limestone.

		Ft.	In.
10.	Zone M. Brown limestone much weathered	0	9
9.	Zone L. Granular grayish limestone containing a large number of specimens of *Hadrophyllum d'orbignyi*	0	2

[1] *Geol. Surv. Ohio*, Vol, I, pt. 1, 1873, pp. 113, 114; also *Ibid.* Vol. VI, 1888, pp. 107, 108

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		Ft.	In.
8.	Zone K. Thin blue limestone alternating with layers of black chert	5	7
7.	Massive blue limestone	1	9
6.	Nodules of chert and layers of cherty brown limestone	4	0
5.	Zone J. Massive blue limestone with some chert	1	3
4.	Thin bedded blue limestone	4	0
3	Zone I. Thin shaly limestone or shale, brown to bluish black in color. It has a strong odor of petroleum and contains the Marcellus fauna	8	10

Columbus limestone

2.	Zone H. "Bone-bed"	..	..
1.	Fossiliferous gray limestone	2	0

This section is the last to the south which gives enough of the Delaware limestone to expose the layer of *Hadrophyllum d'orbignyi*. From here this zone has been traced northward through every important section to Delaware, and, where the base of the formation is exposed, it has always been found about twenty-five feet above the "bone-bed." Because of its apparently constant horizon and persistent occurrence, it has been accorded a place in the general section, and furnishes a basis for the approximate determination of the location, in the formation, of outcrops which contain neither of the formational contacts.

The character of the lower layers of the Delaware limestone is well shown here. At the extreme north end of the cut it appears as a thin calcareous shale resting upon the Columbus limestone. Plate II was taken in a small quarry about one hundred yards to the south of this section and between the highway and the reservoir. It gives an excellent idea of the sharpness of the contact between the Columbus and Delaware limestones, and the shaly character of the portion of rock immediately above the "bone-bed" as it is exhibited in Franklin county.

Fauna collected from the Delaware limestone in the above section:

	Zones.
Hadrophyllum d'orbignyi Edwards and Haime	L
Cystodictya gilberti (Meek)	K
Trematopora sp.	K
Ambocœlia umbonata (Conrad)	J
Chonetes scitulus Hall	J
Chonostrophia reversa Whitfield	I
Leiorhynchus limitare (Vanuxem)	I
Leptæna rhomboidalis (Wilckens)	J
Lingula ligea Hall	J
Martinia maia (Billings)	I
Orbiculoidea lodiensis (Vanuxem)	I

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	Zones.
Orbiculoidea minuta (Hall)	I
Orthothetes chemungensis perversus (Hall)	J
Stropheodonta demissa (Conrad)	J
Stropheodonta inæquistriata (Conrad)	J
Stropheodonta perplana (Conrad)	J
Glyptodesma erectum (Conrad)	K
Tentaculites scalariformis Hall	J

Slate Run.[1]—Two and one-half miles north of the Storage dam, and on the east bank of the Scioto River, are the grounds of the Columbus Fishing Club. The pond is fed by a small stream known as Slate Run, which cuts through the Devonian shales and a part of the limestones. The base of the section, formerly exposed here, has been covered by the filling of the reservoir, but the more important part of the outcrop remains. The section as it was prior to the completion of the dam is as follows:

Ohio shale.

		Ft.	In.
24.	Thin bedded black shale obliquely jointed and containing large spherical concretions	12	6

Olentangy shale.

23.	Pale blue or bluish green soft argillaceous shale	2	0
22.	Rather indefinite layer of flat irregular limestone concretions	0	6
21.	Pale blue or bluish green gritless shale	14	0
20.	Blue limestone containing iron pyrites	0	5
19.	Soft bluish green shale	0	7
18.	Purplish brown shale with trail like markings of blue	0	2
17.	Bluish green shale with concretions of iron pyrites	0	4
16.	Purplish brown shale with markings of blue as above	0	2
15.	Bluish green marly shale with some thin brown layers	5	5

Delaware limestone.

14.	Zone M. Blue and gray to brown thin bedded limestone with layers of black chert	10	8
13.	Zone L. Not found in place. Blocks containing its fauna were found loose in the stream	0	3

[1]See Dr. Prosser's section, *Jour. Geol.*, Vol. XIII, 1905, pp. 426-430.

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The shaly (Marcellus) phase of the Delaware limestone and its contact with the Columbus limestone in a small abandoned quarry along the east bank of the Scioto River, one mile north of Fishinger's Bridge, Franklin County.
(PHOTO BY C. R. STAUFFER.)

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		Ft.	In.
12.	Zone K. Uneven bedded brown limestone and layers of chert	4	4
11.	Zones J and K. Mostly thin even bedded brown limestone with layers of black chert	7	4
10.	Zone J. Thin bedded brown limestone and layers of black chert, both of which are somewhat folded	2	0
9.	Zone I. Brown shale with thin layers of black chert. This is the bank where Dr. Whitfield collected his "Marcellus" fauna	6	0

Columbus limestone.

8.	Zone H. "Bone bed"	..	..
7.	Rather massive crystalline gray limestone	8	0
6.	"Smooth layer"	..	..
5.	Zone G. Massive gray limestone, somewhat weathered	5	0
4.	Covered interval to level of fishing pond	5	4
3.	Partly covered from level of fishing pond to the top of the cliff below the highway	7	6
2.	Zone F and a part of Zone E. Very fossiliferous gray limestone. *Spirifer gregarius* being the must abundant in the upper part	12	0
1.	Covered to former level of the Scioto	5	6

Fauna from the Delaware limestone of this section:

	Zones.
Hadrophyllum d'orbignyi Edwards and Haime	L
Leiorhynchus limitare (Vanuxem)	I
Martinia maia (Billings)	I
Orbiculoidea lodiensis (Vanuxem)	I
Orbiculoidea minuta (Hall)	I
Rhipidomella sp.	K
Spirifer sp.	K
Aviculopecten princeps (Conrad)	M
Glyptodesma erectum (Conrad)	K
Nyassa arguta Hall	K

From the Columbus limestone:

	Zones.
Favosites hemisphericus (Troost)	G
Hadrophyllum d'orbignyi Edwards and Haime	H
Nucleocrinus verneuili (Troost)	H
Atrypa reticularis (Linnæus)	H
Chonetes mucronatus Hall	H
Eunella lincklæni Hall	H
Leptæna rhomboidalis (Wilckens)	H
Nucleospira concinna Hall	H

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	Zones.
Pentamerella arata (Conrad)	H
Reticularia fimbriata (Conrad)	H
Rhipidomella vanuxemi Hall	H
Schizophoria propinque Hall	H
Spirifer acuminatus (Conrad)	H
Spirifer duodenarius (Hall)	H
Spirifer gregarius Clapp	F
Spirifer macrus Hall	H
Stropheodonta hemispherica Hall	H
Paracyclas elliptica Hall	G
Pterinea flabellum (Conrad)	G
Coleolus crenatocinctus Hall	F
Tentaculites scalariformis Hall	H
Callonema lichas (Hall)	H
Euomphalus decewi Billings	G
Platyceras dumosum Conrad	H
Pleurotomaria arata Hall	F
Pleurotomaria lucina Hall	G
Coronura diurus (Green)	G

The limestone, especially that of the Delaware, is thrown into numerous gentle folds, and has a general dip to the southeast, so that an accurate measurement of the formation is rather difficult. In obtaining the above section the bedding planes were followed as much as possible, and the measurement was made with tape and hand level.

Concerning the Brachiopod fauna occurring in the brown shaly zone, No. 9 of this section, Prosser remarks; "It is to be noted that the abundant species of this zone [*Leiorhynchus limitare* (Vanuxem), *Orbiculoidea lodiensis* (Vanuxem), and *Orbiculoidea minuta* (Hall)] occur in the Marcellus shale and later Devonian formations of New York, instead of the Onondaga limestone, and therefore support Whitfield's conclusion that it is the 'equivalent of the Marcellus shale of New York.' "[1]

Hayden Falls.—Hayden Run enters the Scioto River from the west seven miles due northwest of Columbus, and two and one-half miles south of Dublin, at or near the line between Washington and Norwich townships in Franklin county. Some distance from the river this stream enters a narrow rocky gorge, and just before reaching its outlet it tumbles over a ledge of rock, forming a cascade known as Hayden Falls. The following is a section of the rocks exposed along the run:

Delaware limestone.

		Ft.	In.
11.	Zone J. Brown to bluish brown limestone alternating with black chert. Layers from three to six inches thick	8	8
10.	Zone I. Brown shale alternating with layers of brownish black chert. The shale contains the Marcellus fauna	10	8

[1] *Jour. Geol.*, Vol. XIII, No. 5, 1905, pp. 429, 430.

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Columbus limestone.

		Ft.	In.
9.	Zone H. "Bone bed"	..	..
8.	Rather thin even bedded gray limestone containing numerous Crinoid stems and some fossiliferous gray chert	10	8
7.	"Smooth layer"	..	..
6.	Zone G. Massive gray limestone weathering into small blocks of thin uneven beds	21	4
5.	Zone F. Consisting of one or two layers of massive gray limestone forming the top of the ledge over which the water plunges. The *Sp. gregarius* zone	5	7
4.	Zone E. Massive gray limestone weathering into rather thin even layers. The weathered surface is of a light buff color	17	0
3.	Zone D. Layers of fossiliferous chert alternating with thin gray to brown limestone. The chert zone	8	3
2.	Zone C. Massive brown limestone containing a large number of Corals; the usual fauna of the Coral zone	4	5
1.	Covered to the former level of the Scioto River	8	0

Fauna collected at the above locality:

Delaware limestone.

	Zones.
Leiorhynchus limitare (Vanuxem)	I
Orbiculoidea lodiensis (Vanuxem)	I
Tentaculites scalariformis Hall	I

Columbus limestone.

	Zones.
Calcisphæra robusta Williamson	G
Aulacophyllum convergens Hall	G
Aulacophyllum sulcatum (d'Orbigny)	G
Diphyphyllum verneuilanum (Edwards and Haime)	H
Cystiphyllum vesiculosum Goldfuss	G
Diphyphyllum archiaci (Edwards and Haime)	G
Diphyphyllum sp.	G
Favosites hemisphericus (Troost)	G, H
Heliophyllum halli Edwards and Haime	H
Zaphrentis cornicula Edwards and Haime	G
Zaphrentis prolifica Billings	G, H
Zaphrentis wortheni Nicholson	G
Stromatopora ponderosa Nicholson	G
Codaster pyramidatus Shumard	H
Nucleocrinus verneuili (Troost)	H
Cystodictya gilberti (Meek)	G
Fenestella sp.	H
Atrypa reticularis (Linnæus)	E, F

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	Zones.
Atrypa spinosa Hall	F
Athyris vittata indianaensis n. var	E, F
Chonetes mucronatus Hall	E
Cyrtina hamiltonensis Hall	H
Delthyris raricosta Conrad	G
Leptæna rhomboidalis (Wilckens)	H
Pholidostrophia iowaensis (Owen)	H
Productella spinulicosta Hall	H
Rhipidomella cleobis Hall	E
Rhipidomella vanuxemi Hall	G
Spirifer acuminatus (Conrad)	H
Spirifer duodenarius (Hall)	H
Spirifer gregarius Clapp	E, F
Spirifer macrothyris Hall	E
Spirifer macrus Hall	E
Spirifer manni Hall	E
Stropheodonta demissa (Conrad)	G, H
Stropheodonta hemispherica Hall	G, H
Stropheodonta perplana (Conrad)	G
Strophonella ampla Hall	E
Conocardium cuneus (Conrad)	D, G
Glossites teretis (?) Hall	H
Modiomorpha concentrica (Conrad)	D
Paracyclas elliptica Hall	E, G, D
Pterinea flabellum (Conrad)	G
Callonema lichas (Hall)	G
Euomphalus decewi Billings	G
Loxonema pexatum Hall	G
Platyceras dumosum Conrad	H
Pleurotomaria lucina Hall	G
Tentaculites scalariformis Hall	H
Coronura diurus (Green)	E
Phacops cristata Hall	E, G

Perhaps the thing of most importance at Hayden Falls is the appearance of a natural section in which the chert zone (D) occurs, but the resistant character of the *Sp. gregarius* zone is no less interesting. The layer of massive gray limestone with its prominent bedding plane at the base is quite characteristic of this zone throughout the sections along the Scioto River and marks the "fall line" in all of these runs from Dublin southward.

Dublin.—This village is located along the west bank of the Scioto River in Washington township, Franklin county. Many and excellent sections are exposed here, but those usually given are taken from the east bank of the river where there is an outcrop of thirty-three feet of the Columbus limestone with the Delaware limestone showing in the hill above. The section given below may be found along Indian Run, which enters the Scioto from the west at the northern edge of town.

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Some little distance west of the highway this creek divides, and a short distance farther along the south fork is a double cascade, the lower one falling over a ledge of rock which lies in the *Sp. gregarius* zone.

Delaware limestone.

		Ft.	In.
11.	Zone I. Thin bedded fossiliferous grayish brown limestone with but little true shale and not sharply separated from the limestone below	5	10

Columbus limstone.

10.	Zone H. "Bone-bed," poorly defined	..	..
9.	Fairly massive gray limestone containing fish teeth and plates scattered throughout the upper part. This and the zone above may be seen in the old quarry above the upper cascade	8	6
8.	"Smooth layer"	..	..
7.	Zone G. Massive gray limestone along the cascade to the level of the lower waterfall	20	8
6.	Zone F. Massive gray limestone forming the top layers at the waterfall	5	0
5.	Zone E. Rather massive gray limestone and very fossiliferous	20	0
4.	Zone D. Layers of fossiliferous gray chert alternating with grayish brown limestones. The best outcrop is on the north bank below the highway arch	8	4
3.	Zone C. Gray to brown limestone, some quite crystalline. Corals abundant	3	6
2.	Zone B. Massive brown limestone irregularly bedded and obliquely jointed	3	0
1.	Covered to level of the Scioto River	7	4

The following fauna was collected from this locality:

	Zones.
Diphyphyllum archiaci Billings	C, E
Diphyphyllum sp.	C
Favosites emmonsi Rominger	C
Favosites hemisphericus (Troost)	F, G, H
Favosites radiciformis Rominger	C
Zaphrentis cornicula Edwards and Haime	F, G
Zaphrentis gigantea Rafinesque	C, E, F
Zaphrentis prolifica Billings	H
Zaphrentis sp.	E
Stromatopora ponderosa Nicholson	C, E
Megistocrinus spinulosus Lyon	H

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	Zones.
Cystodictya gilberti (Meek)	E, F
Fenestella sp.	H
Monotrypa tenuis (Hall)	E
Polypora robusta (Hall)	E
Atrypa reticularis (Linnæus)	D, E, F, H
Atrypa spinosa Hall	D, E, F, G, I
Camarotœchia billingsi Hall	E
Chonetes mucronatus Hall	F, G
Crania crenistriata (?) Hall	E
Delthyris consobrina (d'Orbigny)	I
Eunella lincklæni Hall	F, H
Leiorhynchus limitare (Vanuxem)	I
Leptæna rhomboidalis (Wilckens)	E, H
Meristella nasuta (Conrad)	D, E
Nucleospira concinna Hall	D
Orbiculoidea lodiensis (Vanuxem)	I
Orthothetes pandora (Billings)	F
Reticularia fimbriata (Conrad)	F, H
Rhipidomella livia (Billings)	E, H
Rhipidomella vanuxemi Hall	D, E, F
Schizophoria propinque Hall	F, H
Spirifer acuminatus (Conrad)	H
Spirifer divaricatus Hall	E
Spirifer duodenarius (Hall)	H
Spirifer gregarius Clapp	E, F, G
Spirifer macrothyris Hall	E
Spirifer macrus (?) Hall	C, H
Spirifer manni Hall	E, F
Stropheodonta concava Hall	H
Stropheodonta demissa (Conrad)	E, H
Stropheodonta hemispherica Hall	D, E, F, H
Stropheodonta patersoni Hall	H
Stropheodonta perplana (Conrad)	E, H
Stropheodonta sp.	F
Strophonella ampla Hall	E
Aviculopecten cf. pecteniformis (Conrad)	H
Conocardium cuneus (Conrad)	D, E, F, G
Limopteria pauperata Hall	E
Modiomorpha concentrica (Conrad)	D, E
Nucula niotica (?) Hall and Whitfield	D
Paracyclas elliptica Hall	E, F
Bellerophon hyalina Hall	D
Bellerophon newberryi Meek	D
Bellerophon pelops Hall	D, E, F
Callonema bellatulum (Hall)	D
Callonema lichas (Hall)	E
Cœlidium strebloceras (?) Clarke	D
Cyclonema crenulatum Meek	D
Euomphalus decewi Billings	F
Isonema depressum Meek and Worthern	D
Loxonema gracillium Whiteaves	D
Loxonema læviusculum Hall	D

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	Zones.
Loxonema parvulum Whitfield	D
Loxonema pexatum Hall	D
Loxonema sp.	D
Macrocheilus sp.	D
Murchisonia desiderata Hall	D
Murchisonia leda Hall	D
Murchisonia maia Hall	D
Murchisonia quadricarinata n. sp	D
Naticopsis æquistriata Meek	D
Naticopsis comperta Hall	D
Naticopsis sp.	D
Platyceras blatchleyi Kindle	H
Platyceras carinatum Hall	E, F
Platyceras cymbium Hall	E
Platyceras dumosum Conrad	H
Platyceras sp.	D
Pleurotomaria adjutor Hall	D
Pleurotomaria dublinensis n. sp	D
Pleurotomaria hyphantes Meek	D
Pleurotomaria lucina Hall	E, F, G
Pleurotomaria regulata (?) Hall	D
Turbo shumardi Verneuil	E, F
Coleolus crenatocinctus Hall	D. E
Tentaculites scalariformis Hall	G, H, I
Gomphoceras eximium Hall	E
Gyroceras columbiense Whitfield	E
Orthoceras ohioensis Hall	D
Coronura diurus (Green)	E
Odontocephalus bifidus Hall	E, H
Phacops cristata Hall	F
Proetus crassimarginatus Hall	D, F, H
Proetus rowii (Green)	F

Corbin's Mill.—At Corbin's Mill, which is located on the east side of the river and less than a mile above Dublin, Orton gives a section which covers all of the Delaware and forty-three feet of the Columbus limestone.[1] His measurement makes the chert zone occur only thirty feet below the "bone-bed," whereas it usually averages from fifty to fifty-five below the top of the Columbus limestone. This is evidently an error, as recent measurements show the interval to be normal. The rocks are somewhat folded and the gully winds considerably, so that errors are easily made. The following section is believed to be essentially correct:

Delaware limestone.

	Ft.	In.
9. Zone K. Thin bedded brown limestone and some chert	13	0
8. Zone J. Much black chert alternating with layers of brown limestone	8	0

[1] *Geol. Surv. Ohio*, Vol. III, 1878, p. 604.

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	Ft.	In.
7. Zone I. Brown shale containing a fauna of *Leiorhynchus limitare*, etc., as found at other localities where this horizon is exposed	5	0

Columbus limestone.

6. Zone H. The "bone-bed" is not clearly shown. The upper part is a thin bedded almost shaly brown limestone	9	0
5. Zone G. A rather massive gray limestone, much weathered	21	0
4. Zone F. Massive gray limestone containing an abundance of fossils, among which *Sp. gregarius* is the most common	4	8
3. Zone E. A very fossiliferous massive gray to brownish gray limestone	17	10
2. Zone D. Layers of fossiliferous gray chert alternating with grayish brown limestone to the base of the cliff	3	1
1. Partly covered to level of the Scioto River	10	9

Although the rocks here are very fossiliferous, no attempt to make a representative collection was made. The few that were picked up are such as were also found along Indian Run.

Franklin-Delaware County Line.—In giving a section of the formation outcropping near this place, Winchell locates it "where the Scioto crosses the southern boundary of the county (Delaware) * * * in descending a ravine from the east, on the land of Abram Butts."[1] This ravine is located about one hundred and fifty yards north of the county line, and the land is now owned by Mr. Arthur Stickel, of Columbus. The small stream flowing through this ravine is sometimes called "Monkey Run." The following is a section of the rocks found here:

	Ft.	In.
6. Soil and drift	5	0

Columbus limestone.

5. Zone F. Massive gray Crinoidal limestone containing many specimens of *Spirifer gregarius*	3	0
4. Zone E. Very fossiliferous gray limestone in massive beds which weather into thin uneven layers and small blocks. The vertical walls show numerous oblique joints and the weathered surface has a gray-brown color	18	10

[1] *Geol. Surv. Ohio*, Vol. II, pt. 1, 1874, p. 297

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	Ft.	In.
3. Zone D. Fossiliferous gray chert in two to four-inch layers alternating with six to twelve-inch layers of crystalline brown limestone	8	6
2. Zone C. The Coral zone appears to be wanting here; at least it is lacking in Corals	..	..
1. Zone B. Massive brown limestone, the upper part of which contains much bituminous matter. Between some of the layers there is a distinctly bituminous shale parting. Uneven beds from two to fourteen inches. It contains pockets of calcite crystals and some unfossiliferous gray chert. Weathered surface buff	13	0

A small but interesting collection of fossils was made at this locality.

	Zones.
Zaphrentis gigantea Rafinesque	E
Zaphrentis sp.	E
Dictyonema leroyensis Gurley	B
Semicoscinium bi-imbricatum (Hall)	D
Unitrypa tegulata Hall	D
Atrypa reticularis (Linnæus)	D, E, F
Chonetes mucronatus Hall	E
Meristella nasuta (Conrad)	D
Rhipidomella sp.	E
Schizophoria propinque Hall	E
Spirifer gregarius Clapp	F
Spirifer manni Hall	D
Stropheodonta hemispherica Hall	E
Conocardium cuneus (Conrad)	E
Bellerophon pelops Hall	D
Isonema humile Meek	D
Murchisonia sp.	D
Platyceras dumosum (?) Conrad	E
Pleurotomaria lucina Hall	E
Coronura diurus (Green)	E
Phacops cristata Hall	F

Winchell thought that from "ten to fifteen feet" of the formation is lacking here, and that his "Delhi beds," which are equivalent to about thirty feet of that portion of the Columbus limestone lying immediately below the base of the Delaware, rest directly upon the chert zone.[1] It is to be noted, however, that the top of this outcrop contains an abundance of *Spirifer gregarius*, and hence lies in Zone F, which is usually located about thirty feet below the "bone-bed" or upper limit of the Columbus limestone. The layers lying immediately above and below

[1] *Idem*, pp. 296, 297.

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this zone frequently present very similar lithological characteristics and likewise weather into small blocks, which fall as talus at the base of the cliffs. That there is no thinning out of a portion of the formation is evident from the section which follows.

Deer Run.—Directly opposite the "section near the south line of Delaware county, in the east bank of the Scioto" which is given above and a section of which Winchell gives, there is a deep gorge cut by Deer Run, which enters the river three and a quarter miles north of Dublin and about an eighth of a mile north of the county line. The section may be found on lands owned by John Dun in Concord township, Delaware county. The cliffs are vertical walls of limestone at places nearly forty feet in height. They are but little weathered, and show the even character of the bedding excellently. This is one of the best outcrops that can be found among the many that occur along the Scioto River.

Columbus limestone.

		Ft.	In.
7.	Zone H. Gray limestone, much weathered.	7	6
6.	Zone G. Massive gray limestone in even beds from ten to fourteen inches in thickness	20	0
5.	Zone F. Massive gray limestone containing numerous specimens of *Spirifer gregarius*	4	5
4.	Zone E. Massive gray limestone in layers from one to two and a half feet in thickness. Where much weathered these heavy beds are broken up into thin uneven layers. Weathered color dark gray, yellowish gray or buff	18	0
3.	Zone D. Layers of fossiliferous gray chert alternating with brownish limestone	7	8
2.	Zone C. The Coral zone is wanting	..	..
1.	Zone B. Massive brown limestone with numerous oblique joints and in the bed of the run broken into irregular jagged blocks. It contains much bituminous matter and some pockets of calcite crystals	8	4

The following fauna was collected along this run:

	Zones.
Favosites hemisphericus (Troost)	G
Zaphrentis cornicula Edwards and Haime	G
Zaphrentis gigantea Rafinesque	F
Zaphrentis sp.	F
Fenestella parallela (?) Hall	D
Polypora robusta (?) (Hall)	D
Prismopora triquetra Hall	D
Stictopora sp.	D
Atrypa reticularis (Linnæus)	D, E, F, G

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	Zones.
Chonetes mucronatus Hall	E, F, G, H
Crania sp.	D
Eunella lincklæni Hall	E, F
Leptæna rhomboidalis (Wilckens)	E
Meristella nasuta (Conrad)	D
Nucleospira concinna Hall	E
Pholidostrophia iowaensis (Owen)	F
Rhipidomella vanuxemi Hall	E
Schizophoria propinque Hall	E, F
Spirifer acuminatus (Conrad)	H
Spirifer divaricatus Hall	E, F
Spirifer gregarius Clapp	E, F, G
Spirifer macrothyris Hall	E
Spirifer macrus Hall	D, E, F
Spirifer manni Hall	E
Stropheodonta hemispherica Hall	D, E, F, G
Stropheodonta perplana (Conrad)	F
Stropheodonta inæquistriata (Conrad)	D, E, F, G
Strophonella ampla Hall	E
Conocardium cuneus (Conrad)	D, E, F, G
Limopteria pauperata (?) Hall	G
Modiomorpha concentrica (Conrad)	E
Mytilarca percarinata Whitfield	D, E
Nucula niotica (?) Hall and Whitfield	D
Paracyclas elliptica Hall	E, G
Bellerophon newberryi Meek	D
Bellerophon pelops Hall	D, E
Callonema bellatulum (Hall)	D
Callonema lichas (Hall)	E, F
Dentalium martini Whitfield	D
Euomphalus decewi Billings	E, G
Isonema depressum Meek and Worthen	D
Loxonema pexatum Hall	D, G
Loxonema robustum Hall	D
Murchisonia desiderata Hall	D
Murchisonia desiderata var. Hall	D
Murchisonia maia Hall	D
Naticopsis æquistriata Meek	D
Orthonema newberryi Meek	D
Platyceras attenuatum Hall	E
Platyceras carinatum Hall	E
Platyceras dumosum Conrad	F
Pleurotomaria adjutor Hall	D
Pleurotomaria lucina Hall	D, E
Pleurotomaria sp.	D
Turbo shumardi Verneuil	D
Coleolus crenatocinctus Hall	F
Gyroceras cyclops Hall	G
Gyroceratites ohioensis Meek	E
Orthoceras ohioense Hall	D, E
Coronura diurus (Green)	G
Phacops cristata Hall	F, G

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A comparison of this section with the preceding one shows them to be practically identical, except that this one has a much greater extension above the chert zone. This indicates that every member of the Columbus, except a small portion of the top which has been removed by erosion, is here represented in its usual thickness. The distance between these two sections is scarcely three hundred yards.

The absence of Corals in the zone where they generally occur is also to be noted. The limestone of this horizon is much darker in color and contains more of the thin bituminous layers at the top than usual. The contact between this lower portion and the overlying chert zone has many of the features of an unconformity, and it may be that this locality was temporarily above the sea, while surrounding areas were supporting a rich Coral fauna. At any rate, conditions here were unfavorable for Coral life, and the presence of a quantity of bituminous matter suggests the presence of plant life. This portion of the formation has a similar appearance at other localities, the most striking of which perhaps is that at Robinson's lime-kiln near Rathbone. Here there are no Corals at this horizon, and the indications of unconformity are so strong that it has been suggested as the dividing line between two formations. The break is, however, not always apparent, nor is the faunal evidence in favor of such a division. Possibly it may be used to advantage to indicate the dividing line between the upper and lower portions of the Columbus limestone—two portions of a single formation divided rather on lithological structure and scarcity of fossils in the lower part than on real faunal differences.

Eversole Run.—This run is located in Concord township, about two miles north of the south line of Delaware county, and enters the Scioto River from the west, flowing between the old Robinson or Courtwright and the Depp farms. It cuts an interesting gorge in the Columbus limestone, of which the following is a section:

Columbus limestone.

		Ft.	In.
4.	Zone E. Massive gray limestone, very fossiliferous, and especially so near the base, where it contains a rather distinct layer of Corals	16	0
3.	Zone D. Gray chert alternating with brown limestone. The best exposure of this zone is at the foot of Robinson hill. A detailed measurement of the chert zone at this locality is given later	5	10
2.	Zone C. Massive brown limestone which near the highway is a mass of Corals	2	0
1.	Zone B. Massive brown limestone, uneven bedded and showing numerous oblique joints. Fossils rare except in the cherty nodules that occasionally occur	19	4

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A rather full collection of fossils from this section yielded the following fauna:

	Zones.
Cladopora pulchra Rominger	B, C
Cladopora robusta Rominger	C
Diphyphyllum simcoense (Billings)	B, C
Diphyphyllum strictum Edwards and Haime	C
Favosites emmonsi Rominger	C, D, E
Favosites hemisphericus (Troost)	D, E
Syringopora tabulata Edwards and Haime	C, D
Zaphrentis cornicula Edwards and Haime	D
Zaphrentis gigantea Rafinesque	B, C, E
Stromatopora ponderosa Nicholson	C, D, E
Coscinium striatum Hall and Simpson	D
Cystodictya gilberti (Meek)	D
Fenestella parallela Hall	D
Fenestella sp.	B
Fistulipora substellata (?) Hall	B
Lichenalia sp.	D.
Monotrypa tenuis (Hall)	D
Nemataxis fibrosus Hall	B, D
Polypora celsipora (Hall)	D
Polypora flabelliformis (?) (Hall)	D
Polypora hexagonalis (Hall)	D
Polypora robusta (Hall)	D
Prismopora triquetra (Hall)	D
Stictopora sp.	D
Atrypa reticularis (Linnæus)	C, D, E
Atrypa spinosa (?) Hall	D, E
Camarotœchia billingsi Hall	B
Camarotœchia tethys (Billings)	C, D
Chonetes mucronatus Hall	D
Crania crenistriata (?) Hall	D
Cyrtina hamiltonensis Hall	D
Delthyris raricosta Conrad	E
Eunella lincklæni Hall	C, D
Leptæna rhomboidalis (Wilckens)	D
Meristella nasuta (Conrad)	B, D, E
Meristella rostrata (?) Hall	C
Nucleospira concinna Hall	D
Orthothetes pandora (Billings)	D
Pholidostrophia iowaensis (Owen)	D
Productella spinulicosta Hall	D, E
Reticularia fimbriata (Conrad)	C, D
Rhipidomella vanuxemi Hall	D, E
Schizophoria propinque Hall	D, E
Spirifer divaricatus Hall	D, E
Spirifer gregarius Clapp	E
Spirifer macrothyris Hall	D, E
Spirifer macrus Hall	B, C, D
Spirifer manni Hall	D, E
Spirifer varicosus Hall	D
Stropheodonta demissa (Conrad)	B, D

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	Zones.
Stropheodonta hemispherica Hall	B, C, D, E
Stropheodonta inæquistriata (Conrad)	C, D, E
Stropheodonta patersoni Hall	E
Stropheodonta perplana (Conrad)	D
Strophonella ampla Hall	B, D, E
Actinopteria boydi (Conrad)	D
Actinopteria sp	C
Aviculopecten cleon Hall	C
Conocardium cuneus (Conrad)	B, D, E
Conocardium cuneus attenuatum (Conrad)	D
Conocardium cuneus trigonale Hall	D
Conocardium ohioense Meek	D
Glossites teretis Hall	D
Goniophora hamiltonensis (?) Hall	D
Grammysia secunda (?) Hall	D
Grammysia subarcuata (?) Hall	D
Modiomorpha concentrica (Conrad)	D, E
Mytilarca percarinata Whitfield	D
Nucula niotica Hall and Whitfield	D
Nucula sp.	D
Paracyclas ohioensis Meek	C, D
Plethomytilus ponderosa Hall	D
Schizodus contractus Hall	D
Schizodus tumidus Hall	D
Solemya vestuta Meek	D
Bellerophon hyalina Hall	D
Bellerophon newberryi Meek	D
Bellerophon pelops Hall	D, E
Bellerophon rotalinea (?) Hall	D
Bellerophon sp.	D
Callonema bellatulum (Hall)	D
Callonema clarki Nettelroth	D
Callonema imitator (Hall and Whitfield)	D
Callonema lichas (Hall)	D, E
Cyclonema crenulatum Meek	D
Dentalium martini Whitfield	D
Euomphalus decewi Billings	E
Isonema depressum Meek and Worthen	D
Isonema humile Meek	D
Loxonema gracillium Whiteaves	D
Loxonema læviusculum Hall	D
Loxonema parvulum Whitfield	D
Loxonema pexatum Hall	D
Loxonema pexatum obsoletum Hall	D
Loxonema robustum Hall	D
Loxonema sp.	D
Macrocheilus hebe Hall	D
Macrocheilus macrostoma Hall	D
Macrocheilus prisca Whitfield	D
Murchisonia desiderata Hall	D
Murchisonia desiderata var. Hall	D
Murchisonia eversolensis n. sp	D
Murchisonia intermedia n. sp	D

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	Zones.
Murchisonia leda Hall	D
Murchisonia maia Hall	D
Murchisonia quadricarinata n. sp	D
Naticopsis æquistriata Meek	D
Naticopsis comperta Hall	D
Naticopsis lævis Meek	D
Platyceras bucculentum Hall	D
Platyceras carinatum Hall	D
Platyceras dumosum (?) Conrad	D
Platyceras thetis Hall	D
Platyceras sp.	D
Platystoma lineatum Conrad	D
Platystoma subglobosa n. sp.	D
Pleurotomaria adjutor Hall	D
Pleurotomaria cancellata n. sp	D
Pleurotomaria cf. capillaria Hall	D
Pleurotomaria dublinensis n. sp	D
Pleurotomaria hyphantes Meek	D
Pleurotomaria insolita Hall	D
Pleurotomaria lucina Hall	D, E
Pleurotomaria plena Hall	D
Pleurotomaria procteri Nettelroth	D
Pleurotomaria sciotoensis n. sp	D
Pleurotomaria sp.	D
Pseudophorus antiquus Meek	D
Straparollus corrugatus n. sp	D
Strophostylas varians Hall	D
Turbo shumardi Verneuil	E
Coleolus crenatocinctus Hall	D, E
Tentaculites scalariformis Hall	D
Agoniatites discoideus (Hall)	D
Cyrtoceras cretaceum Whitfield	E
Cyrtoceras metula (?) Hall	D
Cyrtoceratites ohioensis Meek	D
Gyroceras columbiense Whitfield	D
Orthoceras nuntium Hall	D
Orthoceras ohioense Hall	D
Orthoceras sirpus Hall	D
Orthoceras thoas Hall	D
Chasmops archiops Hall	D
Dalmanties sp.	D
Phacops cristata Hall	D, E

Chert is a rather common constituent of the Columbus limestone, as is also the case in its eastern equivalent, the Onondaga of New York. At Bellefontaine, Whitehouse, Marblehead, Marion, and Columbus rather extensive beds of this material occur, and yet an examination of these various sections shows that in all probability they occur at as many different horizons. They bear different relations to certain faunal groups and other more or less constant features of the formation, but, what is more important, these chert beds have very different faunas.

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Zone D of the above section, and occurring also in many of the previously mentioned sections, lies from fifty to fifty-five feet below the "bone-bed" or top of the formation and immediately above a very prominent fossil Coral reef. The outcrop of this chert zone in Eversole Run is exceedingly fine. (See Plate III). It will be observed, however, that there has been a rapid decrease in its thickness, as compared with sections farther south. This thinning out continues northward until two miles above the Girls' Industrial Home at Rathbone, Delaware county, no trace of it can be found, but at Robinson's lime-kiln (now abandoned), one mile south of the Rathbone bridge and on the east bank of the Scioto River, the zone measures four feet. From thence southward it gradually increases in thickness until at the section exposed during the construction of the Columbus Storage Dam, it has attained the maximum measurement of nine and one-third feet. This zone also forms the floor of the western part of the Columbus Stone Company's quarry at Marble Cliff, but at that point it passes under cover and is lost to observation.

Outcrops of this chert are abundant along the Scioto River and its tributaries from Columbus northward as far as the zone extends. Perhaps the most noted of these is that on the east bank of the river at Dublin, from which locality many of the species figured and described by James Hall and R. P. Whitfield were collected. Orton discusses this zone[1] in connection with his Corbin's Mill section, and Winchell calls attention to it in his "section near the south line of Delaware county,"[2] but his No. 2 includes rather more than is here considered a part of this zone. Some distance below the beds under discussion, occur scattered masses of chert which from their mode of occurrence and scarcity of fossils, are easily distinguished from the upper and more definite zone. It is this lower and almost non-fossiliferous chert which occurs along Mill Creek at Bellepoint.[3]

The best outcrop of this chert zone, so far as a collecting ground is concerned and also as a typical exposure, although slightly diminished in thickness, is at the foot of Robinson hill on Eversole Run. (See Plate III.). Here the zone has a thickness of five and five-sixths feet, consisting of the usual cherty layers alternating with rather thin limestones as follows:

		Inches.
10.	Gray chert and grayish brown limestone intermingled	3
9.	Grayish brown limestone	3
8.	Gray chert and grayish brown limestone	3
7.	Grayish brown limestone	5
6.	Gray chert imbedded in grayish brown limestone but mostly chert which is very fossiliferous	12
5.	Grayish brown limestone	2

[1] *Geol. Surv. Ohio*, Vol. III, 1878, p. 605.
[2] *Idem*, Vol. II, pt. 1, 1874, p. 297. [3] *Idem*, p. 298.

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The outcrop of the chert or Gastropod zone in the Columbus limestone at the foot of Robinson's Hill, along the north bank of Eversole Run, Delaware County.

(PHOTO BY J. E. HYDE.)

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		Inches.
4.	Gray chert with some grayish brown limestone...	9
3.	Grayish brown limestone.....	12
2.	Gray chert imbedded in grayish brown limestone	7
1.	Hard crystalline grayish brown limestone with a few nodules of gray chert in the upper part...	14

The chert occurs mostly as concretionary masses imbedded in the limestone, but sometimes these become so numerous as to practically exclude the latter and form more or less continuous layers of chert alternating with limestone. Much of the chert is hard and flint-like, but some of it, especially where much weathered, is soft and even chalky in appearance.

By far the greater majority of the fossils were obtained from No. 6 of the above section, and likewise No. 1 is especially rich in fine specimens of *Meristella nasuta*, but since most of the specimens were also found to occur in the other portions of the section, the fauna is given together for the whole zone. The fauna is rather remarkable in that many of the species are somewhat under size, but they are all well preserved, and show the smallest external markings excellently, and in some cases even traces of the original color. It is unfortunate, however, that they are frequently much cracked and broken. Perhaps the most remarkable feature about the fauna is the number of Gastropods which it contains.

The chert occurring below the Coral zone of this vicinity, is also of a gray color and fossiliferous, but it differs from that of the true chert zone in its mode of occurrence and in its fauna. It is found scattered irregularly through the limestone, and its meager and poorly preserved fossils cannot be classified as a Gastropod fauna. As the true chert zone (D) disappears, this lower chert becomes more prominent, but never assumes the definite character of Zone D. This part of the formation may also be seen in an excellent cliff on the east bank of the Scioto just opposite the mouth of Eversole Run.

A short distance above the Cox and Thomas mill, and about one and one-half miles south of Bellpoint, thirty-one feet of the massive brown limestone forming the lower part of the Columbus limestone outcrops in a cliff on the west bank of the river. This is capped by three and three-quarters feet of brown limestone, which is but a mass of Corals. In the field near by these are weathering out and lie strewn over the ground much like one might expect to find the fragments along a present day reef. These specimens, however, are not well preserved, and much difficulty was experienced in attempting to identify the fragments picked up. Among the abundant forms, however, the following may be recognized:

Cladopora tela (?) Davis
Cyathophyllum multigematum (?) Davis
Diphyphyllum stramineum Edwards and Haime

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Diphyphyllum strictum (?) (Edwards and Haime)
Favosites emmonsi Rominger
Favosites hemisphericus (Troost)
Zaphrentis gigantea Edwards and Haime

Bellepoint.—This village is located at the junction of Mill Creek and the Scioto River in Delaware county. Opposite the mouth of Mill Creek is an old quarry and a small run. These, combined with the bold cliff-like river bank give the following section.

		Ft.	In.
8.	Soil and drift	2	0

Columbus limestone.

		Ft.	In.
7.	Zone F. Thin layers of gray limestone much weathered. It carries the *Spirifer gregarius* fauna	1	0
6.	Zone E. Very fossiliferous massive gray limestone	17	6
5.	Zone D. Eversole chert wanting	..	..
4.	Zone C. Brown limestone containing numerous Corals	5	4
3.	Zone B. Massive brown limestone with little or no chert	6	0
2.	Massive brown limestone with irregular pockets of fossiliferous gray chert	5	4
1.	Massive brown limestone with oblique joints and showing little or no bedding to Scioto River level	10	8

The following is a list of the fossils obtained here:

Syringopora tabulata Edwards and Haime	B
Zaphrentis gigantea (?) Rafinesque	B, C
Fenestella erectipora (?) Hall	B
Fenestella sp.	B
Nemataxis fibrosus Hall	B
Atrypa reticularis (Linnæus)	E
Meristella sp.	B
Schizophoria propinque Hall	E
Spirifer divaricatus Hall	E
Spirifer gregarius Clapp	E, F
Spirifer macrothyris Hall	E
Stropheodonta hemispherica Hall	E
Strophonella ampla Hall	E
Conocardium cuneus (Conrad)	B, E
Modiomorphia concentrica (Conrad)	E
Plethomytilus ponderosa Hall	E
Bellerophon pelops Hall	E
Pleurotomaria lucina Hall	E
Pleurotomaria sp.	B
Coleolus crenatocinctus Hall	E

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Orthoceras ohioense Hall	E
Orthoceras thoas Hall	E
Coronura diurus (Green)	E
Phacops cristata Hall	E

The complete absence of the chert zone at this locality is perhaps the most important feature of the section. It is true that this particular portion is not well exposed where the section was measured, but just north of the bridge over the Scioto, and on the same side of the river, is an old quarry in which the base is formed by the Coral zone. The limestone above it contains no chert, although it does appear to have at least a part of the chert zone fauna.

Winchell says that "the water in Mill creek, at Bellpoint, is on No. 3 of the * * * section taken near the county line,[1] and has excavated a channel in it to the depth of fifteen feet, * * * Above these layers is a thickness of twelve feet of cherty beds."[2] These "cherty beds" are represented by numbers 2 and 3 of the section given above and are not Zone D of the General Section. This is easily determined by the mode of occurrence of the chert, its relation to the Coral zone, well shown here, and by the character of the rock within which it is imbedded, as well as its meager fauna. The amount of chert is relatively small and most of it is quite soft and chalk-like. It is found in pockets scattered more or less irregularly through the massive brown limestone below the Coral zone. Its fauna is small compared with that of the Eversole chert zone, and the specimens are frequently too poorly preserved to be definitely identified. Probably the best exposure of this chert is at the western edge of the village on the north side of the Mill Creek road. Here during the last few months of 1905 a small quarry was opened and the stone crushed for road material. The pit is entirely in the lower portion of the Columbus limestone, and there is exposed thirteen feet of dark brown limestone, with irregular pockets of soft white chert, capped by one and a half feet of brown limestone, which is best described as a mass of Corals.

Near the bridge across Mill Creek, one mile west of Bellepoint, is a prominent bluff on Mr. Cole's farm. Here the base of the Columbus limestone is shown near the level of the stream. The combined section of this bank and the small quarry and run in the immediate vicinity to the south, gives the following:

Columbus limestone.

	Ft.	In.
6. Zone E. Rather massive gray limestone weathering into thinner beds and quite fossiliferous	5	3
5. Zone D. Wanting	..	..

[1]See p. 62 of this report. [2]*Geol. Surv. Ohio*, Vol. II, pt. 1, 1874, p. 298.

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	Ft.	In.
4. Zone C. Massive brown limestone containing numerous Corals, among which the abundant forms are *Favosites hemisphericus, Zaphrentis gigantea, Diphyphyllum simcoense, Favosites goldfussi,* etc. An excellent outcrop of the fossil reef.....	5	5
3. Zone B. Massive brown limestone containing some Corals,*Favosites maximus,* etc	30	4
2. Zone A. Conglomerate composed of waterworn pebbles of Monroe limestone imbedded in a matrix of brown Columbus limestone	1	6

Monroe limestone.

1. Fine grained drab dolomitic limestone showing a laminated structure. This rock continues to the bottom of Mill Creek channel	2	0

In discussing his section measured at this place, and which will be found to differ materially from the one given above, Winchell calls attention to the relatively constant horizon of the Coral zone, and to its occasional non-fossiliferous character; but he goes on to say that "No. 2 of this section embraces Nos. 2 and 3 of the section at the south county line in the east bank of the Scioto. The thin cherty layers are not so well defined as usual, and the thickness of both is somewhat reduced."[1] If this were true it would mean that the Eversole chert zone normally occurs below the Coral zone. It is a fact that there is frequently a thin layer of Corals lying immediately above this chert, but it has never been found to exceed about eight inches in thickness and often disappears within a few feet. Numerous sections, however, throughout Franklin and Delaware counties prove that the order given in the General Section is correct, and that the chert at the Franklin-Delaware county line, if it has a representative at Bellepoint and vicinity, is equivalent to the few layers of massive limestone overlying the Coral zone. The key to the problem is found in Eversole Run, where all of these zones occur in their true relation to each other.

Klondike Quarry.—This is located near White Sulphur station on the Big Four Railroad five and one-half miles west of Delaware, and two miles above Bellepoint. Wild Cat Run, which enters the Scioto River from the east, passes through the quarry. The section given below is of all the rocks exposed along the run:

Delaware limestone.

	Ft.	In.
11. Scattered outcrops of blue limestone and including the small quarry at the top. In all probability including Zones I, J and K in part.....	20	0

[1] *Idem,* pp. 299, 300.

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Columbus limestone.

		Ft.	In.
10.	Zone H. "Bone-bed"	..	..
9.	Rather massive bluish gray limestone	10	0
8.	Zone G. Massive gray limestone, very fossiliferous	16	7
7.	Zone F. Massive gray limestone containing abundant *Spirifer gregarius*	3	5
6.	Zone E. Massive gray limestone forming the base of the quarry	9	10
5.	Massive gray limestone shown on the right bank of the run	4	0
4.	Zone D. Wanting	..	..
3.	Zone C. Brown limestone containing numerous Corals	4	8
2.	Zone B. Brown limestone weathering gray. It consists of irregular beds from six inches to one foot in thickness, shows a somewhat pitted structure, and contains some calcite crystals	13	4
1.	Covered to Scioto River level	2	3

This section, combined with the preceding one on Mill Creek, gives practically the entire Columbus limestone, although it does not measure up to the average for Franklin and Delaware counties. The absence of the chert zone is again noticeable.

Only a few species were collected at this locality.

	Zones.
Diphyphyllum simcoense Billings	C
Favosites goldfussi d'Orbigny	C
Stromatopora ponderosa Nicholson	C
Nucleocrinus verneuili (Troost)	H
Chonetes mucronatus Hall	F, K
Delthyris consobrina (d'Orbigny)	K
Nucleospira concinna Hall	F
Schizophoria propinque Hall	F
Spirifer gregarius Clapp	F
Spirifer macrothyris Hall	E
Conocardium cuneus (Conrad)	G
Modiomorpha cencentrica (Conrad)	F
Callonema lichas (Hall)	F
Coronura diurus (Green)	E

The Klondike quarry occupies the place where the Colvin lime-kilns were formerly located.[1] Since that time the rock has been extensively removed, the lower part being burned for lime, while the Delaware is crushed and shipped for road material.

The dip of the rock strata southward is greater than the gradient of the Scioto River, hence to the north the stream is flowing on older and

[1]See Prof. Winchell's section, *Geol. Surv. Ohio*, Vol. II, pt. 1, 1874, p. 295.

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older strata. There are still some Devonian outcrops along the river to the north of Klondike quarry and on the hills of the east bank the Columbus limestone has been quarried and burned for lime, but scarcely a mile above White Sulphur station the river is flowing on the drab limestones of the Monroe formation. A half mile below Warrensburg the conglomerate of the base of the Columbus is excellently shown along the road on the east bank nearly twenty feet above the river. A mile north of Warrensburg the Scioto valley is broad and relatively flat; the east wall of the pre-glacial Scioto valley, across which the river has been forced, here retreats rapidly to the eastward, and no more important sections occur near the river channel.

The Olentangy River is the most important tributary to the Scioto. Northward from Columbus it too has a narrow valley with banks often cliff-like. Much of its outcrop is confined to the Devonian shales, but there are some very important sections which expose a large part of both limestones.

High Banks.—The Olentangy shale, the upper formation of the Middle Devonian, forms the lower part of the cliffs along the east bank of the Olentangy river at the boundary line between Franklin and Delaware counties. Here the following section is exposed:

		Ft.	In.
9.	Drift	5	0
	Ohio shale.		
8.	Black shales with some concretions and several gray layers. This is limited below by a layer of large spherical concretions.	64	0
7.	Fissile black shale	21	4
6.	Black shales with some spherical concretions	10	8
	Olentangy shale.		
5.	Soft gray to bluish shales	4	4
4.	Layer of flat bluish limestone concretions	0	4
3.	Bluish gray shales with some layers of black shale	6	4
2.	Layer of flat bluish gray limestone concretions	0	4
1.	Bluish gray and brown shales to level of Olentangy River	5	6

The Olentangy shale is exceedingly poor in fossils in central Ohio, and here not a trace of animal remains was found.

Bartholomew Run[1]—This little stream is located a mile north of

[1] *Idem*, pp. 288, 289.

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the Franklin-Delaware county line, and enters the Olentangy River from the west, heading near Powell. Following is the section of rocks exposed here:

		Ft.	In.
26.	Soil and drift	15	0
	Ohio shale.		
25.	Black shale with large spherical concretions in abundance	16	0
	Olentangy shale.		
24.	Soft bluish shales, the upper part weathered or leached to a yellowish color	3	10
23.	Layer of flat, more or less circular concretions of blue limestone	0	7
22.	Soft blue shales with some brown layers	7	2
21.	Layer of bluish argillaceous limestone	0	6
20.	Bluish shale with some thin bands of brown or black	2	0
19.	Black shale resembling the Ohio shale. It contains many fragments of fossil plants	0	7
18.	Soft blue shale	1	0
17.	Black shale, cut into blocks by joints, and containing some iron pyrites	0	6
16.	Soft blue shale	1	8
15.	Two layers of blue limestone	0	4
14.	Bluish green shales with thin bands of brown shale	2	4
13.	Purplish brown shales with some "worm" trails in blue and fragments of fossil plants	0	3
12.	Soft bluish green shales containing great numbers of small limestone concretions	5	0
11.	Purplish brown shale with some "worm" trails in blue through it and containing a few Bryozoans	0	3
10.	Bluish green shales, soft and gritless, showing some "worm" trails	2	4
	Delaware limestone.		
9.	Zone M. Cherty bluish brown limestone with "worm" trails penetrating it and filled with the blue shales of the overlying formation. In the uppermost part fish teeth and spines, more or less water worn, are common. Some pebbles were also found and iron pyrites is common	0	5
8.	Very cherty bluish brown limestone. Layers rather even and sparingly fossiliferous	9	8

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		Ft.	In.
7.	Zone L. Layer of granular limestone containing numerous specimens of *Hadrophyllum d'orbignyi*. This zone contains much iron pyrites which has weathered to oxide at the surface. Many of the fossils have been replaced by iron.....	0	8
6.	Zone K. Massive blue limestone containing very little chert.....	2	0
5.	Thin bedded layers of shaly brown limestone containing much black chert..	1	0
4.	Blue limestone containing iron pyrites and black chert intermingled and much contorted	4	0
.3	Zone J. Rather massive blue limestone with some black chert and some shaly layers	8	0
2.	Zone I. Thin brown calcareous shale with layers of black chert.....	7	0
1.	Brown limestone, somewhat shaly and probably a part of the Delaware, to level of the run below the highway bridge	2	6

This is one of the few places where the contact between the Olentangy shale and the Delaware limestone may be observed, and it is quite probable that this will not remain free from the debris which is continually sliding down the shale cliff.

The fauna collected contains many of the most characteristic species of the Delaware limestone.

	Zones.
Hadrophyllum d'orbignyi Edwards and Haime.....	L
Cystodictya gilberti (Meek).....	K, L
Trematella arborea (?) (Hall).....	L
Camarotœchia tethys (Billings).....	L
Chonetes mucronatus Hall.....	J, L, M
Chonostrophia reversa (Whitfield).....	J, L
Eunella lincklæni Hall.....	L
Leiorhynchus limitare (Vanuxem.....	I, J
Leptæna rhomboidalis (Wilckens).....	J
Lingula ligea Hall.....	J
Orbiculoidea lodiensis (Vanuxem).....	I
Orbiculoidea minuta (Hall)	I
Pholidostrophia iowaensis (Owen).....	L
Rhipidomella vanuexmi Hall.....	K
Spirifer audaculus macronotus Hall.....	L
Spirifer macrus Hall.....	L
Strophеodonta demissa (Conrad).....	K, L
Strophеodonta hemispherica Hall	L, M
Strophеodonta perplana (Conrad).....	L
Glyptodesma erectum (Conrad)	J
Platyceras erectum (Hall)	J
Tentaculites scalariformis Hall	I, J

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The layer containing *Ligula ligea* lies a little above the center of Zone J, and contains this species in great abundance, and associated with it is *Glyptodesma erectum*. It will be noted that both of these are strictly Hamilton species.

Aside from the plant remains and few worm-like trails, little in the way of fossils was collected from the Olentangy shale at this locality. A fragmentary Pelecypod of undetermined genus, but probably a *Nucula*, a single Crinoid segment, and a probably Bryozoan, constitute the entire collection.

Deep Run.—This run enters the Olentangy River from the east, about a mile and a half north of the preceding section, or two and one-half miles north of the south line of Delaware county. Its gorge gives a fine section of the Devonian shales and part of the limestones, showing a full development of the Delaware.[1]

Ohio shale.

		Ft.	In.
17.	Black shale showing its characteristic nearly right angled system of joints	56	0
16.	Rather fissile black shale weathering brown and containing some large spherical concretions	21	4

Olentangy shale.

15.	Soft bluish gray argillaceous shales. The contact with the overlying Ohio shale well shown	4	0
14.	Irregular flat bluish limestone concretions	0	4
13	Bluish gray shale with some thin layers of brown shale	5	8
12.	A rather definite layer of flat blue limestone concretions	0	2
11.	Soft bluish shale	1	0
10.	Bluish argillaceous limestone	0	4
9.	Soft blue shale	12	0

Delaware limestone.

8.	Zone M. More or less covered at contact with the above shale. A brown limestone	10	0
7.	Zone L. Layer of granular limestone containing *Hadrophyllum d'orbignyi*	0	3
6.	Zone K. Cherty brown limestone	4	4
5.	Bluish brown limestone alternating with black chert and much of it contorted	5	0

[1]See Dr. Prosser's section, *Jour. Geol.*, Vol. XIII, No. 5, 1905, pp. 430, 431; also Prof. Winchell's section, *Geol. Surv. Ohio*, Vol. II, pt. 1, 1874, pp. 293, 294.

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		Ft.	In.
4.	Zone J. Somewhat massive bluish limestone alternating with black chert. *Tentaculites scalariformis* is a very common fossil..	4	10
3.	Zone I. (?) Brown shale alternating with black chert. Somewhat folded.....	7	0
2.	Rather massive layers of brown limestone showing a tendency to split into thinner layers. This rock resembles the deposit at the same horizon along Bartholomew Run and there referred to the Delaware, to which it probably belongs	6	7

Columbus limestone.

1.	No distinct "bone-bed" could be found. Much weathered very fossiliferous blue and gray limestone to level of Olentangy River	21	8

The fauna of this section was not collected.

Case Run.—On the same side of the river, and about one and one-half miles further north, is the farm now controlled by Amelia Case[1]. A small run passing by the house cuts a section which gives practically all of the Delaware limestone, while farther up stream is an interesting cliff, known as "Dripping Rock," where the Olentangy and Ohio shales are exposed. The loose material of this run furnishes one of the finest collecting grounds known for the Delaware limestone.

		Ft.	In.
16.	Black shale with some large spherical concretions	27	8

Olentangy shale.

15.	Bluish gray soft argillaceous shale.....	3	8
14.	Layer of blue limestone concretions.....	0	3
13.	Soft bluish shale.....	3	6
12.	Occasional flattened limestone concretions..	0	4
11.	Soft bluish shale.....	2	0
10.	Layer of bluish limestone.....	0	4
9.	Soft bluish shale mostly covered.....	21	0

Delaware limestone.

8.	Zone M. Massive hard blue limestone with but little chert.....	8	6
7.	Zone L. Granular layer containing *Hadrophyllum d'orbignyi*. This zone is exposed just below the barn.....	0	3

[1]See Prosser in *Jour. Geol.*, Vol. XIII, 1905, p. 432, on which is the halftone shown in Plate iv.

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This illustration shows the thin bedded and cherty character of a large part of the Delaware limestone along Case Run, Delaware County.

(PHOTO BY C. S. PROSSER.)

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		Ft.	In.
6.	Zone K. Layers of blue limestone, six inches in thickness, and thin shaly layers with much grayish brown chert	7	6
5.	Thin bedded blue limestone with some chert	3	6
4.	Zone J. Massive bluish brown limestone with no chert	2	0
3.	Thin shaly brown limestone alternating with layers of black chert	5	10
2.	Thin bedded brown limestone with some irregular nodules of chert	2	0
1.	Zone I. Thin bedded blue limestone to bottom of run at highway bridge	3	8

Most of the following collection was made from the loose material near the highway bridge, hence no horizon can be assigned to it, although it is certainly all from the Delaware limestone.

Aulopora serpens Goldfuss
Zaphrentis sp.
Hadrophyllum d'orbignyi Edwards and Haime
Cystodictya gilberti (Meek)
Monotrypa tenuis (Hall)
Amboccelia umbonata (Conrad)
Camarotœchia prolifica Hall
Chonetes mucronatus Hall
Chonetes scitulus Hall
Cyrtinia hamiltonensis Hall
Delthyris consobrina (d'Orbigny)
Eunella linckæni Hall
Leiorhynchus limitare (Vanuxem)
Leptæna rhomboidalis (Wilckens)
Lingula manni Hall.
Martinia maia (Billings)
Orbiculoidea doria (?) (Hall)
Orbiculoidea lodiensis (Vanuxem)
Orbiculoidea sp.
Orthothetes pandora (Billings)
Pholidostrophia iowaensis (Owen)
Productella spinulicosta Hall
Reticularia fimbriata (Conrad)
Rhipidomella vanuxemi Hall
Rhipidomella sp.
Spirifer macrus Hall
Spirifer sp.
Stropheodonta concava (?) Hall
Stropheodonta demissa (Conrad)
Stropheodonta perplana (Conrad)
Aviculopecten cleon Hall
Aviculopecten princeps (Conrad)
Glyptodesma erectum (Conrad)
Nyassa arguta (?) Hall

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Paracyclas lirata (Conrad)
Platyceras dumosum Conrad
Platyceras erectum (Hall)
Platyceras sp.
Proetus sp.

A striking feature of this outcrop is the shaly character of a large part of the Delaware limestone. (See Plate IV). This same condition may be observed at many of the outcrops along the Olentangy River. Also there is a tendency for the lower layers of the formation to become more massive, although they still carry the Marcellus fauna.

Harter Run.—This run is located just across the river and a half-mile south of the one previously discussed. It is a mile south of Liberty Church and scarcely two miles above the Powell road. There are some very good outcrops along this stream, but the section possesses interest, particularly because of the large amount of Columbus limestone here exposed. It is near the crest of one of the larger of the small east and west anticlines which affect the rocks of the southern part of Delaware county.

Delaware limestone.

		Ft.	In.
6.	Thin bedded brown limestone alternating with layers of black chert. Scattered outcrops belonging to the two lower zones of this formation	15	0

Columbus limestone.

5.	Zone H. Actual contact covered but some of the loose blocks show an excellent "bone-bed"	..	..
4.	Bluish gray Crinoidal limestone in even layers	10	0
3.	Zone G. Scattered outcrops of massive gray limestone	19	8
2.	Zone F. Rather massive gray limestone containing *Spirifer gregarius*	3	4
1.	Zone E. Massive gray limestone partly covered and much weathered in the cliff near the road at Mr. Harter's residence. Bottom of section at the base of the rocks at the highway arch	18	0

The following species were obtained along this run.

	Zones.
Cyathophyllum rugosum Hall	H
Nucleocrinus verneuili (Troost)	H
Atrypa reticularis (Linnæus)	F, G
Camarotœchia tethys (Billings)	H
Chonetes mucronatus Hall	G, H

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	Zones.
Delthyris raricosta Conrad	G
Eunella lincklæni Hall	H
Leptæna rhomboidalis (Wilckens)	H
Martinia maia (Billings)	I
Schizophoria propinque Hall	H
Spirifer acuminatus (Conrad)	H
Spirifer macrus Hall	H
Spirifer gregarius Clapp	F, G
Stropheodonta hemispherica Hall	G, H
Stropheodonta perplana (Conrad)	H
Aviculopecten cleon Hall	H
Conocardium cuneus (Conrad)	G
Limopteria pauperata Hall	G
Paracyclas elliptica Hall	G
Euomphalus decewi Billings	G
Loxonema pexatum Hall	G
Pleurotomaria lucina Hall	G
Turbo shumardi Verneuil	G
Tentaculites scalariformis Hall	H
Gyroceras columbiense Whitfield	G
Gyroceras cyclops Hall	G
Chasmops calypso Hall	H
Phacops cristata (?) Hall	H

A few years ago this run found a subterranean outlet, so that the lower part of its course is now dry most of the time. Underground drainage is quite common in areas where the Devonian limestones form the bed rock. The caves, sinks and big springs along the Scioto River north of Dublin are excellent examples of this phenomenon. Some of these, as for example, those on the John Dun farm just south of Deer Run, are large enough to admit the body of a man, and one may crawl for many yards without meeting any serious difficulty. A similar, though less extensive, set of sinks occur in the vicinity of Bellevue in the northern part of the state. The courses of these underground streams are controlled by the directions of the master joints, and it seems quite probable that these same factors have had a considerable influence even on the surface drainage.

Lewis Center.—The run which flows westward to the Olentangy River from this stop on the Columbus, Delaware and Marion Electric Railroad, cuts a fine section in the Devonian shales, and the larger part of the Delaware limestone, as follows:

Ohio shale.

		Ft.	In.
23.	Black shale with some spherical concretions and some iron pyrites concretions. Also contains some fossil plants	35	0
22.	Soft gray shales with some black layers in the upper part	10	0
21.	Black shales with spherical concretions	25	0

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Olentangy shale.

		Ft.	In.
20.	Soft blue shale	3	4
19.	Layer of flat blue limestone concretions	0	7
18.	Soft greenish blue shale	3	2
17.	Layer of irregular flat limestone concretions and much iron pyrites	0	3
16.	Soft bluish green shales	3	0
15.	Layer of blue limestone	0	5
14.	Soft bluish green shales with some layers of brown to black shale	16	0
13.	Layer of flat irregular limestone concretions	0	7
12.	Soft bluish green shales	1	6
11.	Layer of irregular flat limestone concretions	0	4
10.	Soft bluish green shales	2	0
9.	Layer of argillaceous blue limestone	0	6
8.	Soft bluish green shales, partly covered	8	0

Delaware limestone.

7.	Zone M. Bluish brown, rather massive limestone	9	6
6.	Zone L. Granular limestone containing *Hadrophyllum d'orbignyi*	0	3
5.	Zone K. Fossiliferous bluish brown limestone	0	10
4.	Granular Crinoidal limestone with some fossiliferous gray chert. Corals plentiful	1	3
3.	Layers of brown limestone and black chert much intermixed and contorted	3	0
2.	Bluish limestone alternating with black chert	4	0
1.	Zone J. Massive blue limestone quite fossiliferous to the level of Olentangy River.	5	4

The fauna collected from this region is as follows:

	Zones.
Favosites emmonsi (?) Rominger	K
Hadrophyllum d'orbignyi Edwards and Haime	L
Heliophyllum halli Edwards and Haime	K
Zaphrentis sp.	K
Cystodictya gilberti (Meek)	L, M
Fistulipora vesiculata Hall and Simpson	L
Fistulipora sp	L
Atrypa reticularis (Linnæus)	L, M
Camarotœchia billingsi (?) Hall	K
Camarotœchia tethys (Billings)	K
Camarotœchia sp.	K
Chonetes mucronatus Hall	K, M
Cyrtina hamiltonensis Hall	K
Delthyris consobrina (d'Orbigny)	L
Leptæna rhomboidalis (Wilckens)	K
Pholidostrophia iowaensis (Owen)	L, M

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	Zones.
Productella spinulicosta Hall	K
Rhipidomella vanuxemi Hall	K, M
Spirifer audaculus macronotus Hall	K, L
Spirifer sp.	K, M
Stropheodonta concava Hall	L
Stropheodonta demissa (Conrad)	K, L, M
Stropheodonta perplana (Conrad)	K, M
Aviculopecten princeps (Conrad)	K, M
Conocardium sp.	L
Glyptodesma erectum (Conrad)	K
Grammysia bisulcata (Conrad)	K
Grammysia ovata Hall	K

At Liberty Church, which is just across the river and a little south, there is rather more of the Delaware shown. In the run at that point the shaly lower layers of the formation are exposed, and below these are again found the heavy beds which seem to intervene between it and the underlying formation.

North of this locality there are numerous outcrops of Middle Devonian, but they are hardly as good as that just given and practically duplicates of it in the kind of rock outcropping. One of the better of these sections may be found along Welsh Run, which is on the east side of the Olentangy River and about half way between Lewis Center and Stratford. Here there is an outcrop of thirty-five feet of the Delaware limestone, which is succeeded by a partly covered section of Olentangy shale, and then by an excellent outcrop of the Ohio shale.

Stratford.—The village of Stratford is located three miles south of Delaware. Here the Olentangy River is flowing on strata belonging to the Delaware formation. Several quarries have been opened in this vicinity, but none are being worked at the present time (1909). The limestone is in general more massive and contains less chert than it does farther south, and hence has furnished some excellent building stone for local use. The limestone shows a number of small folds.

The following section is exposed in the quarry by the school house north of the village and in the river at that point.

Delaware limestone.

		Ft.	In.
15.	Crinoidal blue limestone	1	2
14.	Layer of white chert	0	3
13.	Granular masses, of inconstant occurrence along the south side of the quarry, carrying an abundance of *Hadrophyllum d'orbignyi*. This layer is also well filled with fish teeth and spines. Doubtless the Zone L of the General Section	0	6
12.	Cherty layers alternating with blue limestone	4	3
11.	Rather massive hard blue limestone weathering into thin layers	1	9

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		Ft.	In.
10.	Brown shaly limestone, quite fossiliferous..	1	2
9.	Thin bedded blue limestone.....	0	9
8.	Shale parting	0	2
7.	Blue limestone with much bluish white chert and shaly partings	1	6
6.	Rather massive bluish brown limestone with some chert	2	6
5.	Blue limestone with a conspicuous concoidal fracture, some bluish white chert and shaly partings	1	6
4.	Impure blue to brown shaly limestone.....	0	8
3.	A rather massive rough blue limestone, marked with various trails and especially *"Spirophyton cauda-galli"*	0	10
2.	Impure shaly blue to brown limestone.....	0	10
1.	Thin bedded weathered bluish limestone exposed in the river bed.....	1	6

It is quite probable that this section extends down nearly to the Columbus limestone, as a few blocks from the deeper part of the river appear to belong to that formation. The lower part of the section does not show the same shaly character that is observed in the Franklin county sections, but the fauna is suggestive of the same horizon. Even No. 10 of the section carries a *Leiorhynchus*, which is probably *L. limitare*.

The following is the fauna of this locality:

	Horizon.
Hadrophyllum d'orbignyi Edwards and Haime.....	13
Chonetes deflectus Hall.....	6, 10
Chonetes sp.	1
Chonostrophia reversa (Whitfield).....	1, 3
Cyrtina hamiltonensis Hall.....	3
Delthyris consobrina (d'Orbigny).....	1, 2, 4, 5, 6, 10
Leiorhynchus limitare (?) (Vanuxem).....	1, 3, 10
Leptæna rhomboidalis (Wilckens).....	12, 15
Lingula manni Hall.....	10
Lingula sp.	10
Martinia maia (Billings).....	3, 4, 10
Orbiculoidea lodiensis (Vanuxem).....	10
Orbiculoidea doria Hall.....	10
Rhipidomella vanuxemi Hall.....	13
Spirifer sp.	10
Stropheodonta demissa (Conrad).....	10
Stropheodonta hemispherica Hall.....	15
Stropheodonta perplana (Conrad).....	6, 13
Glyptodesma erectum (Conrad).....	6
Grammysia bisulcata (Conrad).....	6
Pterinea flabellum (?) (Conrad).....	6
Sphenotus cuneatus (Conrad).....	6
Platyceras erectum (Hall).....	6
Platyceras sp.	6
Tentaculites scalariformis Hall.....	3, 5, 6, 7

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Delaware.—As far as the limestone is concerned, Delaware Run, at the point where it is crossed by the Hocking Valley Railroad, is the one important locality in this city. Campbell's quarry, on the east side of the railroad tracks, is the older of the quarries, and perhaps the more interesting since it has furnished the stone for the construction of many buildings in the city, and is the locality from which a number of types have been collected. The rock is much less shaly than is usual to the south, and contains but little chert. Near the west side of the quarry there is a fault having about six feet vertical displacement and passing to the south into a distributive fault of greater complexity. The line of fault (strike) runs nearly north and south.

The following section was measured along the southeast side:

		Ft.	In.
12.	Soil and drift	5	0
	Delaware limestone.		
11.	Thin bedded Crinoidal limestone having a grayish brown color	2	0
10.	Layer of fossiliferous grayish white chert	0	2
9.	Thin bedded more or less granular bluish limestone containing Crinoid fragments and *Hadrophyllum d'orbignyi.* (The Zone L of sections farther south)	2	0
8.	Thin bedded bluish gray to brown limestone	3	8
7.	Several layers of rather pure blue limestone	1	8
6.	Blue limestone with much bluish black chert imbedded in it	1	6
5.	Even bedded blue limestone in massive layers from four to twenty inches in thickness and containing very little chert	8	9
4.	Soft bluish limestone containing much white chert. The limestone weathers into a thin shaly clay-like mass releasing the chert	1	0
3.	Rather massive blue limestone in layers from six to fourteen inches thick and containing little or no chert	5	4
2.	Soft shaly blue limestone, very fossiliferous	0	6
1.	Two layers, each two feet, of blue limestone with a thin parting of soft shaly material much like No. 2	4	0

An attempt to locate, here as at Stratford, the various zones recognized further south, was not very successful, hence they have been omitted from the section in both cases. It seems quite probable, however, that the bottom of the quarry is not far above the "bone-bed" or top of the Columbus limestone.

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The following species were found here:[1]

	Horizon.
Hadrophyllum d'orbignyi Edwards and Haime	9, 10
Orthopora regularis Hall	2
Orthopora sp.	2
Chonetes mucronatus Hall	2, 5
Chonostrophia reversa (Whitfield)	
Delthyris consobrina (d'Orbigny)	1, 2, 3, 4
Leiorhyhchus sp.	1
Leptæna rhomboidalis (Wilckens)	1, 3, 5
Spirifer macrus Hall	4
Tentaculites scalariformis Hall	2, 3, 4, 5
Onychodus sigmoides Newberry	3

In addition to these, fragments of plants and fish bones are commonly found. It was from this locality that many of Newberry's types were taken.

Another section at this city, of scarcely less importance, is the cliff of shale along the east bank of the Olentangy River a quarter of a mile below the Big Four Railroad bridge. This is Winchell's type section for the Olentangy shale (see Plate V), since it is the one mentioned by him in naming the formation,[2] and a very exact section of which is given in connection therewith.

The following measurements were made towards the south end of the cliff:

		Ft.	In.
22.	Soil and drift	3	0
	Ohio shale.		
21.	Badly weathered and much altered black shale	8	0
20.	Black shale with some large more or less spherical concretions and some thin arenaceous layers at the contact below	22	0
	Olentangy shale.		
19.	Soft blue argillaceous shale	2	4
18.	Horizon of discontinuous layer of flat blue limestone concretions	..	..
17.	Soft argillaceous blue shale with a few thin layers of brown to black shale	5	4
16.	Soft argillaceous blue limestone	0	4
15.	Soft blue shale	1	4
14.	Brown to black shale with an occasional blue trail in it	0	4
13.	Argillaceous soft blue shale	1	0
12.	Layer of brown to black shale with blue trails	0	1
11.	Argilaceous soft blue shale	2	6
10.	Layer of brown shale with markings of blue	0	1

[1]See Dr. Bownocker's list of species collected and section of rocks at this locality. *Bull. Sci. Lab. Den. Univ.*, Vol. XI, 1898, pp. 22, 23, pl. IV.

[2]*Geol. Surv. Ohio*, Vol. II, pt. 1, 1874, pp. 284, 285, 287.

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The Olentangy shale at N. H. Winchell's type section, along the east bank of the Olentangy River at Delaware. The illustration shows the layers of limestone and the flat concretions so common in the formation. These limestones contain a few poorly preserved fossils.

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		Ft.	In.
9.	Soft blue shale with a half dozen or more thin layers of argillaceous blue limestone, and an occasional flat limestone concretion near the base. Two feet seven inches above the base of this zone there is a remarkable bed of Crinoid fragments about midway along the cliff. It forms a lens of limestone with a maximum thickness of five inches and extends along the cliff for a distance of thirteen and one-half feet	4	10
8.	A persistent layer of flat limestone concretions	0	8
7.	Soft blue shale with an occasional flat disc-like concretion	1	6
6.	Persistent layer of disc-like concretions	0	4
5.	Soft argillaceous blue shale with several discontinuous layers of disc-like or flat concretions	3	0
4.	Rather definite layers of flat irregular limestone concretions	0	5
3.	Soft argillaceous blue shale with a few rather irregular blue limestone concretions	3	4
2.	Argillaceous blue limestone breaking with a very irregular and concoidal fracture	0	4
1.	Soft argillaceous blue shales tending to be massive, to level of Olentangy River	0	4

About a hundred yards down stream from the base of this section the Delaware limestone outcrops in the bottom of the river, the covered interval being probably three feet.

As usual with the Olentangy shale in central and southern Ohio, fossils are rare and in the main, poorly preserved. Aside from the local layer made up of Crinoid stems and fragments, included in No. 9 of the above section, the following fauna was collected:

Melocrinus sp.
Leiorhynchus sp.
Orbiculoidea sp.
Pleurotomaria sp.
Orthoceras sp.

As poor as this fauna is, and as scarce as the specimens are, it is still a fairly good forecast of the rather rich fauna of these beds to the north. While the specimens collected were hardly well enough preserved to admit of certain specific identification, they resemble very closely the species collected from the equivalent of this formation around Sandusky. Outcrops of the Olentangy shale are rare to the north, and its study has been attended with considerable difficulty and an appreciation of the necessarily unsatisfactory condition in which it must be left. Never-

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theless, indications are strongly in favor of the interpretation here put upon the formation; namely, that it thickens materially on approaching the lake region, that it becomes quite fossiliferous, especially in the upper part, and that a limestone is introduced in its upper part and in contact with the overlying Huron shale. The Olentangy shale is thus the equivalent of at least the lower part of Newberry's "Prout limestone and marl." It may be well to state that on starting into the field, with a direct knowledge of only the Olentangy shale and a literature knowledge of the "Prout limestone and marl," exactly the opposite opinion was held, and only after a study of such outcrops of these two phases of the upper Hamilton, as may be found in the northern and central fields did the original conception become untenable.[1]

Waldo.—One of the most troublesome outcrops, and likewise one that is almost too poor to be considered, were good sections accessible, is to be found at the highway bridge across the Olentangy River one-half mile south of Waldo,[2] in the southern part of Marion county. Here the excavation for the east abutment of the iron bridge exposed some of the blue shales, while the calcareous layers are to be found in the bed of the river below the old dam, as well as along the west bank a short distance up stream. The east bank of the river above the dam gives an outcrop of Ohio shale which is scarcely five feet, by hand level, above the hard blue limestone (Delaware?) under the bridge. This would seem to indicate a considerable decrease in the thickness of the Olentangy shale at this point. However, the strata are here affected by small folds, as is the case farther south, and the exact interval is not known. In Crawford county Winchell gives the thickness of this formation as thirty feet,[3] but as there is no outcrop, its thickness may only be obtained from well sections while its fauna remains unknown.

Radnor.—The village of Radnor is located seven miles northwest of Delaware, and about three-quarters of a mile west of the Meredith station on the Hocking Valley Railroad. It is located on the eastern rim of the old drift filled valley of the Scioto. The group of quarries located near this place are the Delhi[4] quarries of Winchell's report. About a mile south of the village and a quarter of a mile west of the highway is the old Jones quarry. It has not been worked in recent years, nor was it ever opened to a very considerable depth, but the section is of interest in the discussion of these formations.

	Ft.	In.
3. Soil and drift.....	5	0

[1]But for Winchell's idea of the age of the Olentangy shale see *Proc. Am. Assoc. Adv. Sci.*, Vol. XXII, pt. 2, 1874, pp. 103, 104.

[2]See Winchell, N. H. *Geol. Surv. Ohio*, Vol. II, pt, 1, p. 287.

[3]*Idem*, p. 243. [4]*Idem*, p. 299

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Columbus limestone.

	Ft.	In.
2. Rather compact gray limestone, very fossiliferous. This is probably a fairly massive rock, but it has weathered into thin beds	10	0
1. Compact slightly crystalline gray limestone containing some fossils, to bottom of the quarry	1	10

The following fauna was collected from this quarry:

	Horizon.
Favosites hemisphericus (Troost)	2
Zaphrentis cornicula Edwards and Haime	2
Zaphrentis gigantea Rafinesque	2
Atrypa reticularis (Linnæus)	1, 2
Rhipidomella vanuxemi Hall	2
Spirifer divaricatus Hall	2
Spirifer gregarius Clapp	2
Spirifer macrothyris Hall	2
Spirifer manni Hall	2
Spirifer sp.	1, 2
Stropheodonta demissa (Conrad)	2
Stropheodonta hemispherica Hall	1, 2
Stropheodonta perplana (Conrad)	2
Strophonella ampla Hall	2
Conocardium cuneus (Conrad)	1
Modiomorpha concentrica (Conrad)	1
Paracyclas elliptica Hall	1
Pleurotomaria lucina Hall	1
Gomphoceras plenum (Beecher)	1
Orthoceras sp.	1

Three-quarters of a mile farther south is the Meredith quarry, which has been opened on a larger scale and is still being worked. Here the following section was measured:

	Ft.	In.
4. Soil and drift	8	0

Columbus limestone.

3. Crystalline light gray limestone, very fossiliferous and especially full of *Spirifer gregarius*. Petroleum oozes from the cavities of the fossils. There can be no doubt but that this is Zone F of the general section	5	10
2. Compact to semi-crystalline gray limestone, fairly fossiliferous	8	6
1. Gray to brown limestone with very few fossils to the bottom of the quarry at the outlet of the spring	4	8

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The following fauna was collected here:

	Horizon.
Calcisphæra robusta Williamson	3
Favosites hemisphericus (Troost)	2
Syringopora tabulata Edwards and Haime	2
Zaphrentis cornicula Edwards and Haime	3
Zaphrentis gigantea Rafinesque	2, 3
Zaphrentis sp.	3
Stromatopora ponderosa Nicholson	2
Stromatopora nodulata Nicholson	2
Stromatopora sp.	2
Cystodictya gilberti (Meek)	3
Atrypa reticularis (Linnæus)	1, 2, 3
Atrypa spinosa Hall	2
Chonetes mucronatus Hall	2, 3
Eunella lincklæni Hall	2
Leptæna rhomboidalis (Wilckens)	3
Pholidostrophia iowaensis (Owen)	2
Productella spinulicosta Hall	2
Rhipidomella vanuxemi Hall	2, 3
Schizophoria propinque Hall	2
Spirifer divaricatus Hall	2
Spirifer gregarius Clapp	2, 3
Spirifer macrothyris Hall	3
Spirifer manni Hall	2, 3
Stropheodonta demissa (Conrad)	1, 2, 3
Stropheodonta hemispherica Hall	2, 3
Stropheodonta perplana (Conrad)	1, 2
Strophonella ampla Hall	2
Conocardium cuneus (Conrad)	2, 3
Modiomorpha concentrica (Conrad)	1, 2
Murchisonia desiderata var. Hall	2
Pleurotomaria lucina Hall	2
Turbo shumardi Verneuil	3
Gyroceras cyclops Hall	2
Dalmantes sp.	3

This fauna shows the presence of Zones E and F of the general section, but the most interesting point here is the occurrence, in the bottom of the quarry, of a limestone which resembles Zone B, both in its paucity of fossils and its physical appearance. On top of these layers there is quite a representation of Corals, but no true Coral zone is visible anywhere. If these bottom layers belong in Zone B, then there is not only an absence of the chert and Coral zones, but a considerable lessening of the interval between Zones B and F, without any apparent indication of a break between the two.

Owen Station.—Along the Hocking Valley Railroad, five miles south of the city of Marion, Mr. Owen has a large quarry cutting both of the Devonian limestones. The rocks are somewhat folded, and have a strong dip to the southeast, bringing the *Spirifer gregarius* zone to the

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This illustration shows the thick bedded character of the Delaware limestone in the east wall of Owen's quarry at Owen Station, Marion County. The camera case rests on the "bone-bed" or top of the Columbus limestone.

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surface at the west side of the quarry, while over eighteen feet of the Delaware is shown along the east side. (See Plate VI). The full section of the quarry follows:

Delaware limestone.

		Ft.	In.
10.	Rather thin layers of blue limestone with much bluish white chert	5	0
9.	Massive and thin layers of blue limestone with some chert and usually shale partings which contain Crinoid stems	5	4
8.	Soft shaly blue limestone containing numerous Crinoid stems	1	0
7.	Thick even bedded blue limestone with shale and cherty partings	3	9
6.	Massive blue limestone in even beds	3	6

Columbus limestone.

5.	"Bone-bed" fairly well shown	..	..
4.	Massive bluish gray limestone not separable lithologically from that below and no smooth layer observed. (Zone H of the Central Ohio section)	10	0
3.	Massive bluish gray limestone in even beds, and containing numerous specimens of *Atrypa reticularis* and *Atrypa spinosa* near the top. (Corresponds to Zone G).	18	0
2.	Massive blue gray limestone limited above by a prominent ripple-marked bedding plane. *Spirifer gregarius* in abundance (Zone F)	2	6
1.	Very fossiliferous fine grained gray limestone, at places showing a blue cast. (Zone E)	14	6

The following species are quite plentiful at this place.

	Horizon.
Favosites emmonsi Rominger	4
Favosites hemisphericus (Troost)	4
Zaphrentis gigantea Rafinesque	1
Stromatopora ponderosa Nicholson	1
Nucleocrinus verneuili (Troost)	4
Cystodictya gilberti (Meek)	4, 6
Fenestella parallela (?) Hall	9
Atrypa reticularis (Linnæus)	1, 2, 3, 4
Atrypa spinosa Hall	3, 4
Camarotœchia tethys (Billings)	7
Chonetes mucronatus Hall	4, 6, 9
Chonostrophia reversa (Whitfield)	7
Delthyris consobrina (d'Orbigny)	7, 9, 10
Leptæna rhomboidalis (Wilckens)	7, 9
Productella spinulicosta Hall	6

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	Horizon.
Rhipidomella vanuxemi Hall	4, 9
Schizophoria propinque Hall	4
Spirifer acuminatus (Conrad)	4
Spirifer duodenarius (Hall)	4
Spirifer gregarius Clapp	1, 2, 3
Spirifer macrus Hall	7
Stropheodonta concava (?) Hall	7
Stropheodonta hemispherica Hall	3, 4
Conocardium cuneus (Conrad)	1, 2, 3, 4
Bellerophon pelops Hall	2
Callonema lichas (Hall)	3
Palæotrochus kearneyi Hall	1
Platyceras bucculentum (?) Hall	6
Coleolus crenatocinctus Hall	1
Tentaculites scalariformis Hall	6, 9
Gyroceras cyclops Hall	1

This is an excellent place to study the two limestone phases of the Middle Devonian. The Columbus limestone is easily distinguished and compares very favorably with the same formation in Delaware and Franklin counties, even the zones being readily distinguishable. In general the rock is more massive and of a darker color, the blue predominating. It is a finer grained stone, and would probably make a superior building material were it not for the heavy bedding which makes it hard to work. The Delaware, on the other hand, differs decidedly even from that found at Campbell's quarry, to which its basal layers bear some resemblance. The lower part is a rather pure blue limestone, but the upper part contains much bluish white chert.

Marion.[1]—There are a number of quarries located in and around Marion. Most of them are located north and west of the city, and the larger ones are grouped along the Hocking Valley Railroad tracks about a mile northwest of the Union station. The first quarry of the group lying on the east side of the tracks, is the John Evans quarry, while that just across the tracks to the west is the Norris and Christian quarry. The rocks dip rather sharply to the east, so that the former of these quarries contains much more of the Delaware limestone, while the latter has a greater opening in the Columbus limestone.

The combined measurements of these two quarries give the following section:

Delaware limestone.

		Ft.	In.
13.	Granular Crinoidal blue limestone	3	0
12.	Bluish brown limestone in rather thin even layers alternating with a great quantity of soft bluish white chert. The chert contains Bryozoans	12	6

[1]See also Swartz, Charles K. *Op. cit.* p. 61.

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		Ft.	In.
11.	Rather massive layers of blue limestone with pockets of fossiliferous white chert and thin shaly partings	9	6
10.	Soft shaly blue limestone	0	6
9.	Massive blue limestone with some chert and shaly partings	5	6

Columbus limestone.

8.	"Bone-bed"	..	..
7.	Fossiliferous gray limestone	2	0
6.	Layer of Crinoidal gray limestone	2	0
5.	Massive gray limestone, somewhat Crinoidal and very fossiliferous	10	0
4.	Layer of hard gray chert alternating with gray limestone, both fossiliferous	4	0
3.	Massive gray limestone at places crowded with specimens of *Atrypa spinosa* and *Atrypa reticularis*	3	0
2.	Massive layers of very fossiliferous light gray limestone	12	6
1.	Massive gray to light brown limestone, sparingly fossiliferous, to bottom of quarry	8	6

In making the following collection of species, more attention was given to the Delaware limestone, since it is the greater variable. The collection from the Columbus limestone can hardly be considered as representative.

	Horizon.
Calcisphæra robusta Williamson	5
Favosites hemisphericus (Troost)	3
Syringopora tabulata Edwards and Haime	4
Zaphrentis cornicula Edwards and Haime	3
Stromatopora ponderosa Nicholson	3
Cystodictya gilberti Meek	9, 10, 12, 13
Fenestella sp.	11, 12
Atrypa reticularis (Linnæus)	3, 5, 10
Atrypa spinosa Hall	3, 5
Camarotœchia billingsi Hall	9
Chonetes deflectus Hall	10
Chonetes mucronatus Hall	5, 9
Chonetes sp.	9, 11
Cyrtina hamiltonensis Hall	10, 13
Delthyris consobrina (d'Orbigny)	9, 11, 12, 13
Leptæna rhomboidalis (Wilckens)	9, 10, 11
Orthothetes pandora (Billings)	10
Pentamerella arata (Conrad)	5
Pholidostrophia iowaensis (Owen)	13
Productella spinulicosta Hall	9, 10
Rhipidomella vanuxemi Hall	11
Rhipidomella sp.	9, 11, 12, 13
Schizophoria propinque Hall	5

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	Horizon.
Spirifer acuminatus (Conrad)	4, 5
Spirifer duodenarius (Hall)	7
Spirifer gregarius Clapp	2
Spirifer sp.	5, 10
Stropheodonta concava Hall	13
Stropheodonta demissa (Conrad)	9, 11, 13
Stropheodonta hemispherica Hall	3, 5
Stropheodonta sp.	5, 13
Conocardium cuneus (Conrad)	5
Bellerophon sp.	13
Platyceras carinatum Hall	10
Platyceras dumosum Conrad	4
Platyceras nodosum Conrad	12
Platyceras sp.	9
Pleurotomaria sp.	13
Tentaculites scalariformis Hall	9, 10, 11, 12
Gyroceras cyclops Hall	2
Gyroceras sp.	5, 13
Phacops sp.	13

About a mile and a half northeast of this group of quarries, there is another group which is located along the Pennsylvania Railroad tracks. The larger of these openings is the Central Ohio quarry, of which the following is a section:

		Ft.	In.
7.	Soil and drift	6	0

Columbus limestone.

		Ft.	In.
6.	Rather massive bluish gray to brown fossiliferous limestone	1	2
5.	Bluish gray limestone with quite a number of fish bones and teeth in the upper part, but in general with few fossils	2	10
4.	Layer of *Diphyphyllum verneuilanum*	0	3
3.	Massive crystalline bluish gray limestone, very fossiliferous	10	6
2.	Bluish earthy limestone with a great quantity of white chert and containing very few fossils	4	0
1.	Massive bluish gray limestone. This portion is very fossiliferous and contains great numbers of *Atrypa reticularis* in the upper part	10	4

The following fauna is a very fair representative of that which is to be found here:

	Horizon.
Calcisphæra robusta Williamson	1, 3
Cystiphyllum vesiculosum Goldfuss	6
Diphyphyllum verneuilanum (Edwards and Haime)	4

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	Horizon.
Diphyphyllum sp.	1
Favosites hemisphericus (Troost)	3
Stylastrea anna Whitfield	1
Syringopora tabulata Edwards and Haime	1
Zaphrentis cornicula (Edwards and Haime)	1, 3
Zaphrentis prolifica Billings	3
Zaphrentis sp.	1, 2, 3
Stromatopora sp.	1
Cystodictya gilberti (Meek)	3
Atrypa reticularis (Linnæus)	1, 3
Chonetes mucronatus Hall	1, 3
Leptæna rhomboidalis (Wilckens)	6
Orthothetes pandora (Wilckens)	3
Pentamerella arata (Conrad)	3
Productella spinulicosta Hall	3
Rhipidomella vanuxemi Hall	1, 3
Spirifer acuminatus (Conrad)	3
Spirifer duodenarius (Hall)	6
Spirifer manni Hall	3
Spirifer sp.	3
Stropheodonta demissa (Conrad)	1, 3
Stropheodonta hemispherica Hall	1, 3
Stropheodonta perplana (Conrad)	1, 3
Conocardium cuneus (Conrad)	1
Paracyclas elliptica Hall	3
Loxonema sp.	3
Pleurotomaria sp.	3
Gomphoceras sp.	1

This section extends practically to the top of the Columbus limestone. A short distance to the north of the Central Ohio quarry is the Hamilton quarry, in which a portion of the lower part of the Delaware limestone is exposed. The dividing line between the two formations is not always clear in this region, since at many places they seem to grade into each other. But the doubtful portion (No. 6 of above section) never exceeds two feet, and since it contains an occasional specimen of *Spirifer duodenarius*, it is referred to the Columbus limestone.

The quarries at Marion still produce a considerable quantity of lime. This is the southernmost locality at which the Columbus limestone is being burned on a large scale, except at White Sulphur, west of Delaware, where some is still produced. The industry, however, is on the decline throughout the central part of the state, as is evidenced by the abandonment of the kilns and the introduction of crushers in some of the large quarries where none were in use a short time ago. Within the last few years the kilns of some of the large Marion quarries have been abandoned, while others are seldom used. Such has been the history of the lime industry all over that portion of the state where the Devonian limestones have been employed, and probably will be even at Marble-

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head and Kelley's Island, the greatest stronghold of the industry as connected with these formations. The rock makes a superior lime, although it air-slacks readily, and thus its shipping qualities are depreciated; but the increasing demand for crushed rock is requiring nearly the entire output of these quarries, except that used for building purposes and for furnace flux.

It has been noted that at Marion and Owen Station the rock strata are thrown into broad low anticlinal and synclinal folds. The axes of these folds have, in general, a westerly trend, and possibly tie up with the Shelby-Akron arch.[1] In addition there has been an upwarp of the entire region, so that here the "bone-bed" lies two hundred feet higher than at Columbus, and over three hundred feet higher than at Sandusky. The Bellefontaine outlier is believed to be an expression of this same disturbance and not necessarily a remnant which indicates the former crossing of this portion of the Cincinnati arch by these formations, for Lima and Findlay are probably at the summit of the axis. Under this interpretation it is perhaps proper to treat this outlier here in connection with the central strip to which it is more closely related.

Cable.—This village is located on the Pennsylviana Railroad, ten miles northeast of Urbana, Champaign county. A short distance south of the Pennsylvania Railroad tracks and scarcely a mile southwest of Cable station, is a small quarry, the southernmost known outcrop of the Devonian outlier. The section here, and along the run which passes through the pit, is as follows:

Columbus limestone.

		Ft.	In.
6.	Massive, very fossiliferous gray limestone The stone is very much weathered.....	3	0
5.	Massive and thin layers of bluish gray limestone much weathered and at places partly covered	14	0
4.	Fairly massive brown limestone containing much fossiliferous gray or white chert.	3	0
3.	Compact grayish brown limestone, thin bedded and somewhat banded.....	2	4
2.	Layer of arenaceous gray limestone.....	0	10

Monroe formation.

1.	Thin bedded hard compact drab limestone with a laminated structure. This extends to the lower part of the run near the highway, where it goes under cover	10	8

[1]Orton, Edward, *Geol. Surv. Ohio*, Vol. VI, 1888, pp. 57, 58.

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Fauna of above section:

	Horizon.
Calcisphæra robusta Williamson	6
Diphyphyllum sp.	4
Favosites goldfussi d'Orbigny	4
Favosites hemisphericus (Troost)	6
Pleurodictyum problematicum Goldfuss	4
Zaphrentis cornicula Edwards and Haime	6
Cystodictya gilberti (Meek)	6
Cystodictya sp.	4
Fenestella sp.	4
Amphigenia elongata (?) (Vanuxem)	4
Atrypa reticularis (Linnæus)	6
Atrypa spinosa Hall	6
Camarospira eucharis Hall	4
Eunella sp.	4
Metaplasia disparalis Hall	4
Meristella sp.	5
Orthothetes pandora (Billings)	4
Pholidostrophia iowaensis (Owen)	6
Spirifer divaricatus Hall	4
Spirifer gregarius Clapp	6
Spirifer sp.	4, 6
Strophalosia cf. truncata Hall	4
Stropheodonta demissa (Conrad)	6
Stropheodonta hemispherica Hall	6
Stropheodonta inæquiradiata Hall	6
Stropheodonta parva (?) Hall	4
Stropheodonta perplana (Conrad)	4
Actinopteria boydi (Conrad)	6
Conocardium cuneus (Conrad)	6
Paracyclas elliptica Hall	6
Schizodus contractus Hall	6
Schizodus tumidus Hall	6
Bellerophon pelops Hall	6
Dentalium martini Whitfield	6
Loxonema pexatum Hall	4, 6
Murchisonia desiderata Hall	6
Murchisonia maia Hall	4
Platyceras sp.	4
Pleurotomaria lucina Hall	6
Pleurotomaria sp.	4
Coleolus crenatocinctus Hall	6
Odontocephalus ægeria Hall	4
Phacops cristata Hall	6
Proetus crassimarginatus Hall	4

This section is of importance because of its rather extensive fauna, and because of the diminished thickness of the lower or sparingly fossiliferous part of the Columbus limestone. No. 6 of the section given above is very fossiliferous, and the most abundant species is *Spirifer gregarius*. Whether this is the same zone (Zone F) that has been noticed in the

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vicinity of Columbus, is perhaps not determinable, but it carries a fauna which supports that view. The arenaceous layer, No. 2 of the section, might perhaps be called a sandstone. Sand is a common constituent of the limestones of this region[1] and its presence, even at the base of the formation, is probably of no special geological significance except as a possible indication of land conditions near by. The Cable region was mapped as Silurian by the earlier Survey, and apparently the drift is immediately underlain by that system in the greater part of it. The outcrop here discussed is doubtless but a detached fragment of the great outlier to the north.

West Liberty.—This place is located on the Big Four Railroad, and also on the electric line, about twelve miles south of Bellefontaine. There are many outcrops of Devonian limestone to the east of town, but none of them are extensive. The Gen. Piatt quarry is the most interesting and also the most important opening made in the rocks of this locality. It was from the lower part of this quarry that the stone was taken for the construction of the "Castle" in which the General resides, as well as for the son's mansion, and for the beautiful new school building in West Liberty. The building stone, however, is Monroe limestone. The quarry is located two miles east of town on lands now occupied by Mrs. Frances Piatt, and has the following section:

Columbus limestone.

		Ft.	In.
6.	Very fossiliferous gray limestone. The lower part is a conglomerate composed of Monroe limestone pebbles imbedded in the gray limestone	2	4

Monroe limestone.

5.	Compact hard drab limestone containing such Corals and *Meristelloid* Brachiopods as occur in the upper part of the Silurian at Sandusky	1	8
4.	Rather massive, somewhat banded gray limestone showing a tendency to split into thin uneven layers. Unfossiliferous	5	0
3.	Massive layer of gray banded fine grained limestone without fossils	12	0
2.	Massive gray limestone, banded and rather fine grained. Hackel-toothed upper surface. Unfossiliferous	2	5
1.	Massive layer of brown limestone banded with darker brown. Unfossiliferous	4	7

[1] *Geol. Surv. Ohio*, Vol. III, 1878, pp. 485, 486.

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The fauna of the top of the Monroe was considered only to make certain that it is Silurian. The following is the Devonian fauna from the top layers of the quarry.

	Horizon.
Calcisphæra robusta Williamson	6
Favosites hemisphericus (Troost)	6
Stylastrea anna Whitfield	6
Zaphrentis cornicula Edwards and Haime	6
Atrypa reticularis (Linnæus)	6
Atrypa spinosa Hall	6
Chonetes mucronatus Hall	6
Eunella lincklæni Hall	6
Nucleospira concinna Hall	6
Pholidostrophia iowaensis (Owen)	6
Stropheodonta hemispherica Hall	6
Spirifer gregarius Clapp	6
Conocardium cuneus (Conrad)	6
Paracyclas elliptica Hall	6
Schizodus tumidus Hall	6
Callonema cf. bellatulum (Hall)	6
Euomphalus decewi Billings	6

This is the same fauna as that collected from No. 6 of the Cable section, and is doubtless contemporaneous with it. Here, however, it rests directly on the Silurian limestone.

Bellefontaine.—On the west side of this city the Bellefontaine Stone and Lime Company has quarried extensively in the Columbus limestone. The sections of the various pits are essentially the same, the following being that of the east opening.

Columbus limestone.

		Ft.	In.
7.	Thin weathered layers of gray limestone	5	0
6.	Massive porous layers containing Corals and Brachiopods	3	0
5.	Massive and thin bedded gray to drab dolomitic limestone not in even courses. Fossils rare and those that do occur are in the form of moulds. Some pockets of white chert	11	8
4.	Gray limestone with pockets of fossiliferous white chalky chert	0	6
3.	Two massive layers of dark gray to brown limestone with some chert	4	8
2.	More or less pockety fossiliferous white chalky chert	0	2
1.	Layers of from four to eight inches of a yellowish gray banded to drab limestone. Some brecciated layers and a little chert extending to the water level in the deepest part of quarry	4	0

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The white cherts are usually full of fossils, but the limestone contains few, and those but poorly preserved.

Following is the fauna collected here.[1]

	Horizon.
Favosites emmonsi Rominger	6
Favosites hemisphericus (Troost)	6
Zaphrentis sp.	6
Cystodictya gilberti (Meek)	2
Fenestella sp.	2
Atrypa reticularis (Linnæus)	6
Athyris vittata indianaensis n. var	2
Camarotœchia tethys (Billings)	2
Chonetes deflectus Hall	2
Chonetes mucronatus Hall	2
Cyrtina hamiltonensis Hall	2
Pholidostrophia iowaensis (Owen)	2, 6
Rhipidomella vanuxemi Hall	2, 6
Spirifer acuminatus (Conrad)	2, 4
Spirifer sp.	2
Stropheodonta demissa (Conrad)	2
Stropheodonta hemispherica Hall	2, 5, 6
Stropheodonta perplana (Conrad)	2
Strophonella ampla (?) Hall	5
Glyptodesma occidentale Hall	2
Modiomorpha concentrica (?) (Conrad)	6
Bellerophon newberryi Meek	2
Naticopsis lævis (?) Meek	2
Platyceras dumosum Conrad	2
Platyceras sp.	2
Pleurotomaria sp.	6
Trochonema meekanum Miller	5
Coleolus crenatocinctus (?) Hall	5
Tentaculites scalariformis Hall	2

The bottom of this quarry is probably well down towards the top of the Silurian. This seems apparent from the outcrop of Monroe lime stone in the quarry at Big Springs, two miles northeast of Rushsylvania, where the top layers along the west side of the quarry are composed of a similar rock. Fish teeth and dermal plates are frequently found in these quarries, but no "bone-bed." In fact there is no natural dividing line between the lower deposits, which are surely Columbus limestone, and those above that may be Delaware in this whole outlier. There is a gradual transition upward into more and more arenaceous beds, and finally the abrupt change to the Ohio shale without the intervention of the Olentangy shale.

Zanesfield.—These upper layers are well shown at the George Grubb quarry, in the southern part of the town of Zanesfield, six miles

[1]See Dr. Bownocker's list. *Bull. Sci. Lab. Den. Univ.*, Vol. XI, 1898, pp. 35, 36, 37.

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southeast of Bellefontaine, and along a small run across the highway to the north. The following is the section along the run at this place:

Ohio shale.

		Ft.	In.
5.	Black shale, as much as a hundred feet exposed along the road	4	0
4.	Covered interval which north of this locality was found to be Ohio black shale	5	0

(*Possibly Delaware Limestone.*)

3.	Six to eight-inch layers of hard arenaceous blue limestone with very few fossils	11	0
2.	Arenaceous gray limestone with some fossiliferous gray to white chert	1	2
1.	Hard arenaceous gray limestone in six to eight inch beds to bottom of outcrop	6	0

And in the Grubb quarry the following rocks are uncovered:

(*Possibly Delaware limestone.*)

		Ft.	In.
10.	Massive gray limestone, hard and silicious	4	0
9.	Gray to white banded chert	0	3
8.	Massive gray limestone, hard and silicious	4	8
7.	Massive gray limestone containing moulds of Corals	1	9
6.	Fossiliferous gray chert	0	4
5.	Thin bedded gray limestone with a reddish cast. Contains some Corals	1	8

(*Probably Columbus limestone.*)

4.	Gray limestone with some fossils and containing a considerable amount of chert	2	6
3.	Massive gray limestone with some white chert	2	0
2.	Covered with waste from the quarry	3	8
1.	Fossiliferous gray limestone forming the base of the old quarry	1	6

The fossils in the rocks of this section are too poorly preserved for positive identification, but in addition to a few Corals, Crinoid stems and Bryozoans, the following genera were recognized in this quarry: *Rhipidomella, Dentalium, Loxonema* and *Pleurotomaria.*

East Liberty is located four miles east of Zanesfield, on the Toledo and Ohio Central Railroad, and about ten miles southeast of Bellefontaine, in Logan county. There are several quarries to the west of this

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place, but the one furnishing the most interesting section is to be found on the Armstrong farm one mile and a quarter northwest of town. In a small run just south of the house some quarrying has been done, and the following section is there exposed:

Delaware limestone (??).

		Ft.	In.
8.	Very hard pyritiferous layers of crystalline blue limestone containing some fish teeth and Crinoid stems. The Ohio shale is not exposed here, but these layers are probably those lying immediately below it, where the two formations are seen together	10	0
7.	Rather thin layers of grayish or brown limestone with some chert, few fossils and much iron pyrites	14	8
6.	Bluish gray limestone alternating with layers of gray somewhat chalky chert	3	2
5.	Bluish gray even bedded limestone and containing little or no chert	3	8
4.	Massive layer of Crinoidal gray limestone containing a number of Corals. The fresh surface of this rock shows a reddish cast	2	3

Columbus limestone.

3.	Massive bluish gray hard crystalline limestone, sparingly fossiliferous	5	4
2.	Layer of gray limestone containing some fossils	2	0
1.	Rough hard limestone forming the lowest part of the outcrop in the bed of the run	2	0

In this quarry also no clear distinction between the lower and upper limestones is possible, for the upper portion is so poor in fossils, and so far has yielded none that are distinctively Delaware, that the basis for division is completely gone. The total thickness of the Devonian limestone strata of the Bellefontaine outlier was not definitely determined, but a combination of sections seems to indicate that it probably does not greatly exceed "one hundred feet."[1] Probably the whole deposit should be called Columbus limestone, the Delaware being absent, as is its kindred formation, the Olentangy shale.

Among the poorly preserved fossils, the few that were collected and are recognizable are:

	Horizon.
Favosites hemisphericus (Troost)	3
Zaphrentis sp.	6
Atrypa reticularis (Linnæus)	3
Rhipidomella sp.	6

[1]Hill, Franklin C., *Geol. Surv. Ohio*, Vol. III, 1878, p. 485.

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	Horizon.
Stropheodonta hemispherica Hall	6
Spirifer acuminatus (Conrad)	3
Spirifer sp.	6
Trochonema meekanum Miller	6

On the adjoining farm to the east Mr. Bell has opened a small quarry just west of his house, where the following section is exposed:

Columbus limestone.

		Ft.	In.
5.	Scattered outcrops of grayish brown limestone with a little chert. This portion is shown along the run above the quarry	9	0
4.	Chert and cherty limestone forming the top layer in the old quarry	0	6
3.	Layer of porous brown limestone	1	0
2.	A layer consisting mostly of chert and cherty limestone	0	8
1.	Massive light brown, rather porous limestone with irregular bedding. Quite fossiliferous, but the fossils are poorly preserved and generally in the form of moulds	13	8

The following is the fauna of the lowest division of the section:

Calcisphæra robusta Williamson
Favosites hemisphericus (Troost)
Stylastrea anna Whitfield
Zaphrentis cornicula Edwards and Haime
Stromatopora ponderosa Nicholson
Cystodictya gilberti (Meek)
Fenestella sp.
Atrypa reticularis (Linnæus)
Atrypa spinosa Hall
Chonetes mucronatus Hall
Cyrtina hamiltonensis Hall
Nucleospira concinna Hall
Spirifer gregarius Clapp
Stropheodonta demissa (Conrad)
Stropheodonta hemispherica Hall
Paracyclas elliptica Hall
Bellerophon pelops (?) Hall
Callonema bellatulum Hall
Dentalium martini Whitfield
Pleurotomaria sp.
Tentaculites scalariformis Hall

In addition to these, Crinoid stems are to be found, but they are a common constituent of the fossiliferous portion of the Columbus limestone everywhere. This fauna is so similar to the Cable fauna as to sug-

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gest that it is below the middle of the formation. The section certainly lies below that given for the Armstrong quarry, and probably below or at the horizon of the very bottom of the East Liberty Stone Company's quarry, which is located along the railroad a mile west of the East Liberty depot, and a section of which follows:

Columbus limestone.

		Ft.	In.
3.	Thin bedded and massive layers of grayish brown limestone containing some chert and few fossils except moulds of Corals	24	0
2.	Gray limestone alternating with layers of grayish white chert	3	10
1.	Massive gray or grayish brown limestone with very little chert. Fossils more plentiful than in other parts of the quarry, but still rare	11	2

In the lower part of the quarry only a few fossils were collected, and among these the identifiable ones are: *Favosites hemisphericus*, *Stropheodonta demissa*, *Stropheodonta hemispherica* and *Platyceras dumosum*.

The basal portion of this quarry is not so fossiliferous as is the lower part of the section on the Bell farm, but the lithological structure is much the same, and the few fossils that do occur are not adverse to the view that they are possibly at the same horizon.

Middleburg.—The town of Middleburg is located in the northern part of Zane township, and about two and one-half miles south of East Liberty. The old quarry located in the northern edge of the village is the Sharpe quarry of the early survey and is still known by that name, although no longer worked. Here the following section is exposed:

Columbus limestone.

		Ft.	In.
7.	Gray to brown rather thin bedded limestone	1	8
6.	Chalky and hard white chert, very fossiliferous	0	3
5.	Very fossiliferous gray limestone, containing *Calcisphæra robusta* in great numbers	2	10
4.	Layer of grayish brown hard limestone with some chert at the base	1	8
3.	Gray limestone, probably massive but weathered into thin layers. Quite fossiliferous	4	0
2.	Two rather massive layers of gray limestone showing a reddish cast, the weathered surface often brick red. The upper surface is stylolitic and ochreous. The two layers are separated by an inch or two of chert	5	4

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	Ft.	In.
1. Massive gray to brown limestone quite fossiliferous. *Calcisphæra robusta*, *Favosites hemisphericus*, etc., common. (The layer bears a striking resemblance to the "Bottom rock" of Marblehead and Kelley's Island quarries)	7	9

This is one of the most interesting localities, and perhaps the best collecting ground of the Bellefontaine region.

The following species are from this quarry:

	Horizon.
Calcisphæra robusta Williamson	1, 5, 6
Favosites hemisphericus (Troost)	1
Stylastrea anna Whitfield	5
Syringopora tabulata Edwards and Haime	5
Fenestella sp.	5
Athyris vittata indianaensis n. var	5
Atrypa reticularis (Linnæus)	1, 5
Atrypa spinosa Hall	5
Chonetes mucronatus Hall	5
Cyrtina hamiltonensis Hall	6
Nucleospira concinna Hall	5
Pentamerella arata (Conrad)	6
Pholidostrophia iowaensis (Owen)	6
Rhipidomella sp.	5
Spirifer acuminatus (Conrad)	5
Spirifer duodenarius (Hall)	5
Spirifer gregarius Clapp	5
Stropheodonta demissa (Conrad)	3, 5, 6
Stropheodonta hemispherica Hall	1, 2, 5
Stropheodonta perplana (Conrad)	6
Actinopteria boydi (Conrad)	6
Conocardium cuneus (Conrad)	5, 6
Bellerophon acutilira (?) Hall	6
Callonema lichas (Hall)	6
Cyclonema sp.	5
Loxonema pexatum Hall	6
Loxonema sicula (?) Hall	6
Coleolus crenatocinctus Hall	5
Chasmops calypso Hall	6
Phacops cristata Hall	5, 6

The horizon of this section is probably about that of the Bell quarry, and consequently well down towards the base of the formation, but lithologically and structurally it stands alone—at least so far as outcrops seen are concerned.

Rushsylvania.—This village is located along the Big Four Railroad ten miles northeast of Bellefontaine. One and one-half miles east

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of here, Mr. Peter Roberts has opened a quarry just south of his barn, where the following section is exposed.

Columbus limestone.

		Ft.	In.
11.	Thin bedded arenaceous gray limestone....	2	0
10.	Covered interval	0	6
9.	Layers of thin bedded arenaceous gray limestone with pockets of chert. Contains some Corals	8	2
8.	Hard crystalline gray limestone, red with iron and containing some gray chert. All much weathered	8	4
7.	Massive fossiliferous gray limestone. Common fossils are *Atrypa reticularis, Atrypa spinosa, Rhipidomella vanuxemi, Strophеodonta hemispherica,* etc.	2	2
6.	Hard crystalline blue limestone containing much chert and showing deep stylolitic structure. Contains *Rhipidomella vanuxemi*	2	8
5.	Two layers of hard gray limestone in which no fossils were seen.....	1	8
4.	Massive compact gray limestone in two layers. Among other Corals, *Favosites emmonsi* was recognized.....	3	0
3.	Soft porous gray limestone becoming hard when exposed to the air.....	0	10
2.	Two eighteen-inch layers of gray limestone with some chert between.....	3	0

Monroe limestone.

1.	Compact drab banded limestone, rather massive	3	0

Nearly seven feet of this section was covered with water, but Mr. Roberts kindly furnished the measurements for Nos. 1, 2 and 3, and pointed out blocks of each that had been quarried and were then lying in the higher part of the quarry. Fossils are not abundant in the rock here, but careful collecting would give a much more extensive fauna than the few mentioned in the above section. The section may be compared with that of the Sharpe quarry at Middleburg, since they probably both belong to the same horizon, except that the Roberts quarry extends downward into the Monroe limestone.

A careful consideration of these sections, taken at various points over the Bellefontaine outlier as compared with sections of the similar horizon in the central part of the state, brings out the following facts: (*a*) The lower comparatively unfossiliferous portion of the Columbus

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limestone has been somewhat reduced in thickness, or may be wanting entirely, as at the Gen. Piatt quarry. (*b*) In general the fossiliferous portion contains fewer specimens, and all are rather poorly preserved. (*c*) The upper portion of the Devonian limestone is arenaceous and very impure, but it resembles the Delaware limestone neither in composition and structure nor in its fauna. (*d*) There is neither a "bone-bed" nor any other recognizable horizon marker dividing the limestone into two formations, and probably no such division should be made. (*e*) The Olentangy shale is wanting, the Ohio shale resting directly upon the limestone. (*f*) So far as the fauna goes then, there is an hiatus of the entire Hamilton period. It is probable that this deposit represents the off-shore conditions of the earlier Middle Devonian, and that during the latter part the sea had retreated eastward not to return until the black shale conditions were inaugurated. The Devonian hills of the Bellefontaine region are sometimes called "the Summit of the State," since they contain its greatest elevation above tide. The angle of the dip of the rocks is low and in various directions, but it is probable that the elevation of this portion of the formation relative to other portions has changed very materially since its original deposition.

Bucyrus.—The outcrops near this place are west of the city and mostly along Broken Sword Creek. The best of these, and also the most accessible, is in the quarry of the Broken Sword Stone Company, at Spore, six miles northwest of Bucyrus on the Toledo and Ohio Central Railroad. Here the following section is exposed:

Delaware limestone.

		Ft.	In.
12.	Hard blue limestone, containing a great many specimens of *Delthyris consobrina*, *Leptæna rhomboidalis*, etc.....	1	8
11.	Soft blue shaly limestone containing many Crinoid stems and various trails.....	0	3
10.	Thin bedded and rather massive layers of very hard blue limestone.....	2	6
9.	Soft blue shaly parting.....	0	1
8.	Hard blue limestone in layers from three to six inches thick and quite fossiliferous..	3	8
7.	More or less granular bluish gray limestone containing many Corals and Crinoid stems	0	10

Columbus limestone.

6.	"Bone-bed," best developed along the east side of the quarry.....	..	..
5.	Thin bedded blue limestone containing an abundance of *Spirifer duodenarius*.....	2	8

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		Ft.	In.
4.	Very fossiliferous gray limestone, rather massive but splitting into thin layers....	10	8
3.	Rather massive gray limestone which is very fossiliferous. *Stropheodonta* and *Rhipidomella* are the predominating genera..	4	0
2.	Compact very hard bluish gray limestone with some chert and few fossils.....	4	0
1.	Crystalline gray limestone with much petroleum	3	0

The limestones are remarkably free from chert. The fauna, while rich in individuals, is comparatively poor in species. The following is a fair representation of the fauna here:

	Horizon.
Calcisphæra robusta Williamson.....	1, 3, 4
Diphyphyllum verneuilanum (Edwards and Haime)..	5
Favosites hemisphericus (Troost).....	1, 3, 4
Heliophyllum sp.	7
Stylastrea anna Whitfield.....	4
Syringopora tabulata Edwards and Haime.....	2
Zaphrentis cornicula Edwards and Haime.....	3, 4
Zaphrentis sp.	2, 5
Cystodictya gilberti (Meek).....	4
Fenestella sp.	4
Monotrypa tenuis (Hall).....	4
Atrypa reticularis (Linnæus).....	2, 3, 4, 5, 12
Atrypa spinosa Hall.....	1
Camarotœchia carolina Hall.....	4
Camarotœchia sp.	5
Chonetes mucronatus Hall.....	3, 4
Chonetes scitulus Hall.....	12
Cyrtina hamiltonensis Hall.....	8
Delthyris consobrina (d'Orbignyi).....	8, 10, 12
Eunella lincklæni Hall.....	2, 12
Leptæna rhomboidalis (Wilckens).....	4, 5, 8, 10, 12
Orthothetes pandora (Billings).....	4
Rhipidomella vanuxemi Hall.....	3, 4, 12
Spirifer duodenarius (Hall)	5
Spirifer macrus Hall.....	4
Stropheodonta demissa (Conrad).....	1, 2, 3, 4, 12
Stropheodonta hemispherica Hall.....	3, 4, 5, 10
Stropheodonta perplana (Conrad).....	3, 4, 5
Strophonella ampla Hall.....	1
Conocardium cuneus (Conrad).....	4
Paracyclas elliptica Hall.....	10
Platyceras erectum Hall.....	8
Phacops sp.	5

Bloomville.—This town is located on the Pennsylvania lines, ten miles southeast of Tiffin. To the east and north of this place several small openings have been made for quarrying purposes, and the lime-

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stone also outcrops along the streams, but by far the most important is the France quarry, one and one-half miles east of town, where the following section may be found:

Delaware limestone.

		Ft.	In.
11.	Compact blue Crinoidal limestone.....	2	0
10.	Bluish gray limestone containing a good many Corals and Blastoids. The most important Coral is *Cystiphyllum vesiculosum*	2	0
9.	Rather massive bluish gray limestone splitting unevenly when quarried. This portion is very fossiliferous.....	5	0
8.	Blue to brown limestone containing a small amount of chert.....	2	4
7.	Impure blue limestone with much white chert. The chert runs through the limestone in all directions like ropes. Sometimes there is a parting of blue shale between layers and this is often full of fossils....	12	4
6.	Massive layer of Crinoidal blue limestone...	1	6
5.	Shaly blue limestone parting.....	0	1
4.	Massive layer of Crinoidal blue limestone...	1	6
3.	Bluish black shale parting.....	0	1
2.	Six-inch layer of blue limestone with shale partings	2	0

Columbus limestone.

1.	Massive blue limestone, very fossiliferous..	5	6

At this place the Delaware limestone is quite fossiliferous and especially so in the upper part. The following fauna was collected from this section:

	Horizon.
Cystiphyllum vesiculosum Goldfuss.....	10
Zaphrentis sp.	10
Nucleocrinus venustus (?) Miller and Gurley.....	10
Cystodictya gilberti (Meek).....	2, 7, 9
Fenestella sp.	1, 2
Trematopora sp.	2
Atrypa reticularis (Linnæus).....	2, 9, 10
Atrypa spinosa Hall.....	1, 9
Camarotœchia billingsi Hall.....	9
Camarotœchia tethys (Billings).....	9
Camarotœchia sp.	1, 10
Chonetes mucronatus Hall.....	1, 9
Chonetes scitulus Hall.....	7
Chonetes sp.	2, 7, 10
Chonostrophia reversa (Whitfield).....	9

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	Horizon.
Cyrtina hamiltonensis Hall	2,9
Delthyris consobrina (d'Orbigny)	9
Leptæna rhomboidalis (Wilckens)	1,2,7,9
Pholidostrophia iowaensis (Owen)	9
Rhipidomella vanuxemi Hall	2,10
Spirifer duodenarius (Hall)	1
Spirifer varicosus Hall	1
Spirifer sp.	2,9
Stropheodonta concava Hall	2,9
Stropheodonta demissa (Conrad)	2,9
Stropheodonta hemispherica Hall	1,9
Stropheodonta parva (?) Hall	9
Stropheodonta perplana (Conrad)	1,9
Aviculopecten cleon (?) Hall	9
Aviculopecten princeps (Conrad)	9
Conocardium cuneus (?) (Conrad)	9
Glyptodesma erectum (Conrad)	9
Mytilarca sp	9
Paracyclas elliptica Hall	9
Schizodus sp.	9
Pleurotomaria sp.	9
Platyceras bucculentum Hall	9
Platyceras sp.	7
Tentaculites scalariformis Hall	1,2,7,9
Gyroceras sp.	1,9
Phacops rana Green	10
Phacops sp.	9
Proetus crassimarginatus (?) Hall	1
Proetus rowii (Green)	9
Proetus sp.	2,9

The section is an extremely interesting one from the fact that it shows so much of the Delaware limestone. The fauna, however, is rather disappointing, because it fails to show many of the distinguishing features which separate it from the Columbus. The Coral layer (No. 10 of the Section) is, however, a most interesting zone since it occurs also in the quarries of the Sandusky region, and thus it affords a means of tying sections together. The specimens of *Cystiphyllum vesiculosum*, which are the most abundant, simply lie on top of the layer of limestone and cover it more or less completely to a depth of two or three inches. Sixteen inches below the Coral zone there is a layer which is frequently filled with *Cyrtina hamiltonensis*.

Bellevue.[1]—This city is in the center of an important group of Devonian outcrops, and in a region where the drift is usually thin. Sinks are not uncommon to the north and west, while to the east rock outcrops even along the roadside. The more important limestone outcrops are west of the city.

[1]See also Swartz, Charles K., *Johns Hopkins Univ. Cir.*, N. S. No. 7, 1907, pp. 60, 61.

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The Spence Brothers quarry is located along the Nickel Plate Railroad two miles southwest of Bellevue, and cuts the following section:

		Ft.	In.
12.	Drift and soil	6	0

Columbus limestone.

11.	Hard compact layers of bluish gray limestone, fracturing more or less concoidal	4	0
10.	Compact gray to bluish gray limestone	2	8
9.	Thin bedded uneven layers of very fossiliferous gray limestone. The top layer contains a distinct horizon of *Spirifer acuminatus* associated with *Aviculopecten cleon* (?) as on Kelley's Island	5	0
8.	Comparatively thin bedded gray limestone, very fossiliferous and with a *Spirifer acuminatus* horizon at the top	4	0
7.	Four to ten-inch layers of quite fossiliferous bluish gray limestone	2	10
6.	Layers of a hard gray limestone more or less mottled with white and quite fossiliferous	2	3
5.	A massive layer of fine grained gray limestone	3	3
4.	A massive layer of fine grained gray limestone with some chert in the lower part. (This is probably the "bottom rock" of the Marblehead and Kelley's Island section)	6	4
3.	Layer of gray limestone with no chert	0	10
2.	Light gray chert alternating with layers of grayish brown limestone	2	4
1.	Massive brown limestone with no chert to the bottom of the pit at the crusher	6	6

The following fauna was collected from the upper portion of the quarry:

Diphyphyllum simcoense (Billings)
Favosites hemisphericus (Troost)
Zaphrentis cornicula Edwards and Haime
Atrypa reticularis (Linnæus)
Atrypa spinosa Hall
Camarotœchia tethys (?) (Billings)
Chonetes mucronatus Hall
Cyrtina hamiltonensis Hall
Leptæna rhomboidalis (Wilckens)
Schizophoria propinque Hall
Spirifer acuminatus (Conrad)
Spirifer macrus Hall

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Stropheodonta demissa (Conrad)
Stropheodonta hemispherica Hall
Stropheodonta inæquiradiata Hall
Stropheodonta perplana (Conrad)
Aviculopecten cleon (?) Hall
Aviculopecten princeps (Conrad)
Paracyclas elliptica Hall
Platyceras dumosum Conrad
Proetus crassimarginatus Hall

Garrigan's quarry, (now belonging to the Bellevue Stone Co.), one and one-half mile west of Bellevue along the Wheeling and Lake Erie Railroad, has a very similar section, and is cut to about the same depth. It is about a mile north of the Spencer quarry.

The quarry of the Bellevue Stone Company is located just beyond the western edge of the city, and here the following section is well exposed:

	Ft.	In.
7. Soil and drift	2	0
Columbus limestone.		
6. Very fossiliferous crystalline gray limestone much weathered and the fossils usually in a poor state of preservation	7	0
5. Gray limestone without chert and fossils rare	3	6
4. Gray to brown limestone with white chert between the layers. The chert is all more or less fossiliferous but that in the lower part is very fossiliferous	6	6
3. Two massive layers of gray to brown limestone with but few fossils	8	6
2. A layer of bluish gray and rather crystalline limestone with few fossils	2	6
Monroe limestone.		
1. Massive bluish to drab fine grained banded limestone in layers running from two to three feet in thickness. The top of the upper layer is shaly and has a weathered appearance	17	3

The following fauna was collected in the Devonian portion of this quarry:

	Horizon.
Calcisphæra robusta Williamson	6
Favosites hemisphericus (Troost)	2, 3
Hadrophyllum d'orbignyi (?) Edwards and Haime	4
Syringopora sp.	4

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	Horizon.
Zaphrentis cornicula Edwards and Haime	2, 3, 6
Zaphrentis sp.	4
Stromatopora ponderosa Nicholson	2, 3
Cystodictya gilberti (Meek)	4, 6
Fenestella sp.	6
Semicoscinium semi-rotundum (?) (Hall)	4
Athyris vittata indianaensis n. var	4
Atrypa reticularis (Linnæus)	2, 3, 4, 6
Atrypa spinosa Hall	4, 6
Camarotœchia carolina Hall	4
Camarotœchia tetys (Billings)	4
Chonetes mucronatus Hall	4, 6
Cyrtina hamiltonensis Hall	4
Eunella lincklæni Hall	6
Eunella sullivanti Hall	4
Nucleospira concinna Hall	4, 6
Pholidostrophia iowaensis (Owen)	4, 6
Productella spinulicosta Hall	4
Reticularia fimbriata (Conrad)	4
Rhipidomella vanuxemi Hall	4, 6
Schizophoria propinque Hall	4
Spirifer gregarius Clapp	2, 3
Spirifer manni Hall	6
Spirifer varicosus Hall	4
Stropheodonta demissa (Conrad)	4, 6
Stropheodonta hemispherica Hall	2, 3, 4, 6
Stropheodonta inæquiradiata Hall	4
Stropheodonta perplana (Conrad)	6
Conocardium cuneus (Conrad)	4, 6
Ptychopteria (?) sp.	4
Callonema sp.	4
Platyceras carinatum Hall	4
Platyceras dumosum Conrad	4
Platyceras sp.	4

Strong's Ridge is located three miles east of Bellevue. The ridge is made up of the limestone (Prout) member of the Olentangy, at places capped by the Huron shale, and but slightly covered by drift. Over an area of several square miles around this village outcrops of this uppermost member of the Hamilton are quite common. Among these perhaps the best is to be found on the Allen Farr farm on the Bellevue road, three-quarters of a mile northeast of the village of Strong's Ridge and just across the line in Erie county. The following section is just west of the buildings and north of the highway, where a little quarrying has been done.

	Ft.	In.
9. Soil and drift	2	0

Huron Shale.

8. Black bituminous shale	5	0

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Olentangy formation.

		Ft.	In.
7.	An outcrop of badly weathered bluish limestone. Formerly this was quarried.....	9	0
6.	Soft blue shale, much weathered.....	2	6
5.	Layer of bluish limestone which is made up almost entirely of Bryozoans.....	0	3
4.	Quite fossiliferous compact blue limestone..	0	6
3.	Bluish shale or shaly limestone.....	2	2
2.	Rather compact fossiliferous blue limestone.	0	4
1.	Fossiliferous weathered blue shale showing in the bottom of the ditch.....	2	0

The following fauna was collected in the weathered material of the soft limestones and shales along the ditch bank just below the pond at this place:

Syringopora perelegans Billings
Cystodictya sp.
Monotrypa sp.
Trematopora sp.
Ambocœlia umbonata (Conrad)
Chonetes deflectus Hall
Leiorhynchus kelloggi Hall
Schizophoria striatula (Schlotheim)
Spirifer pennatus (Atwater)
Spirifer sp.
Stropheodonta demissa (Conrad)
Aviculopecten fasciculatus Hall
Modiomorpha subalata (Conrad)
Mytilarca cf. carinata Hall
Pleurotomaria capillaria (?) Conrad
Phacops rana (Green)

This is the most southerly point at which this fauna, in such great abundance, is accessible. Dr. Newberry agreed that it is of Hamilton age, but gave the deposit little consideration beyond that assertion. The fossiliferous limestones and shales of the upper portion of the formation doubtless increase in importance to the north, until at Thedford, Ontario, the whole of the Hamilton is made up of beds similar to those of this section.

Norwalk.—A noted, and perhaps the best, well record of northern Ohio is that known as the "Citizens' well No. 1, Norwalk, Ohio." This well was drilled in 1887 along the banks of the Huron river in Norwalk. The measurements of this section were faithfully recorded by Hon. C. H. Gallup, and the samples preserved by the same gentleman, now form one of the valuable assets of the Firelands Historical Society Museum at Norwalk, Ohio.

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The following gives a brief description of the samples of that portion of the section[1] which is of most interest here:

		Feet.
i.	Drift (Samples No. 1-5)	76
h.	Ohio shale (Nos. 6-13). Black and gray shales showing the usual three-fold division	175
g.	Ohio shale and the Prout limestone member of the Olentangy mixed (14). This sample is mostly a black shale with but little limestone	28
f.	Olentangy shale, Prout limestone member, (15). Gray limestone but the sample containing fragments of black shale	5
e.	Olentangy shale (16). Limestone softer and finer than that above and approaching the shaly phase	5
d.	Olentangy shale (17). A soft mud-like sample. Mr. Gallup says that the drill went about four feet every time it was dropped in this portion	59
c.	Olentangy shale (18). Soft blue shale with some pieces of black shale and some chips of blue limestone	13
b.	Delaware and Columbus limestones (19,20). Chipped blue and gray limestones	130
a.	Monroe limestone (21-50). Dolomitic limestone and gypsum	665

The well is twenty-seven hundred and twenty-five feet deep, and is believed to end in the Trenton limestone. The section gives between eighty and one hundred feet as the thickness of the Olentangy, and about one hundred and thirty feet for the combined thickness of the Columbus and Delaware limestones.

Sand Hill.—This village is located at the old Seven-Mile house along the pike south-southwest of Sandusky. A little more than a quarter of a mile west of the village, and a mile southeast of Weyers station on the Pennsylvania Railroad, is the Barnes quarry (see Plate VII), where the following section is exposed:

		Ft.	In.
11.	Soil and drift	1	0

Delaware limestone.

10.	Bluish gray limestone weathering into thin, rather uneven layers. Few fossils	4	0
9.	Fairly massive blue limestone containing quite a number of Brachiopods, fish teeth, etc.	2	6

[1]Gallup. C. H., *The Firelands Pioneer*, N. S., Vol. XII, 1900, pp. 522-526

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		Ft.	In.
8.	Rather thin bedded blue limestone weathering brown. It contains some white chert and much bituminous matter. The shaly partings contain Crinoid stems and Bryozoans	2	10
7.	White chert	0	4
6.	Brown to blue thin bedded and slightly bituminous limestone with some Crinoid stems but other fossils rare	1	2
5.	Two layers of blue limestone with a few nodules of chert in the lower course	1	4
4.	White chert containing *Leptæna rhomboidalis*	0	4
3.	Blue limestone	2	6
2.	Soft blue Crinoidal limestone with a great quantity of *Leptæna rhomboidalis* bearing white chert in the top	0	10
1.	Two layers of blue limestone completing the section to the bottom of the hole in the southwest part of the quarry	2	2

The fauna here is not rich in species, nor are individuals always plentiful, but the following were picked up and demonstrate its Delaware age.

Fistulipora multiculeata Hall
Camarotœchia sp.
Chonetes coronatus (Conrad)
Cyrtina hamiltonensis Hall
Leptæna rhomboidalis (Wilckens)
Martinia maia (Billings)
Platyceras bucculentum Hall
Platyceras dumosum Conrad
Tentaculites scalariformis Hall

Southward from Sand Hill the Delaware limestone is at the surface, or nearly so, for a mile or two. Mr. Barnes, owner of the quarry, says that on lands now owned by Mr. Parker, a neighbor, a well sunk ninety-six feet with a diamond drill, a few years ago, penetrated ninety feet of blue limestone, and that only the last core of the well was gray. A similar well drilled at Mr. Barnes' own home, penetrated sixty feet of blue limestone and did not pass through it. This is what should be expected, however, since the upper part of the Columbus limestone at Sandusky has a color and texture remarkably similar to that of the Delaware limestone, and the Marblehead sections give only about forty-five feet as the thickness of the gray and brown portions of the Columbus limestone.

Three-quarters of a mile east-southeast from Sand Hill the road crosses Pipe Creek about a quarter of a mile west of Bloomingville. Both above and below the highway bridge at this point there are meager out-

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PLATE VII.

The Delaware limestone in the north wall of the Barnes quarry at Sand Hill near Sandusky. This is probably the upper part of the formation.

(PHOTO BY F. CARNEY.)

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crops of the soft blue shales of the Olentangy. At the barn on the east bank, near the bridge, is an artesian well, which is said to penetrate "fifty feet of soapstone," and to end in the hard blue limestone.

A quarter of a mile east of Bloomingville, a small south branch of Pipe Creek cuts a section in the Prout member of the Olentangy, and also exposes a portion of the shale, north of the ridge road. The following is a section of the rocks at this place:

Olentangy formation.

		Feet.
4.	Blue limestone containing many Crinoid stems, Corals and Bryozoans. *Atrypa reticularis* and *Stropheodonta demissa* are rather common. The limestone has been quarried to some extent	9
3.	Blue shales and limestones, very poorly shown but weathered blocks of it lie on the bank, where such fossils as the following have weathered out: *Syringopora perelegans, Monotrypa sp., Chenetes deflectus, Leiorhynchus kelloggi, Schizophoria striatula, Spirifer pennatus, Stropheodonta demissa, Phacops rana,* etc.	15
2.	Badly weathered marly blue shale	10
1.	Blue shales with disc-like blue limestone concretions. No fossils seen	5

The outcrop of the upper portion of this section is very good, but the shaly banks below are mostly sodded and the section unsatisfactory, except at a few places where the stream strikes the bank at an angle and thus keeps a fresh exposure.

Prout.—This station lies seven miles due south of Sandusky on the Baltimore and Ohio Railroad. The section which Newberry discusses[1] for this locality is about a mile north of the little village, and where the railroad cuts the highest portion of the ridge, or old lake beach. The section now exposed at this point is as follows:

		Ft.	In.
7.	Sand and gravel	14	0
	Huron shale.		
6.	Black shale with a layer of iron pyrites at at the base	2	0
	Olentangy shale, Prout limestone member.		
5.	Dark gray to black chert	0	4
4.	Compact gray limestone, hard and crystalline	1	8

[1] *Geol. Surv. Ohio*, Vol. II, pt. 1, 1874, p. 190.

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		Ft.	In.
3.	Soft shaly blue limestone with numerous Corals	1	2
2.	Mostly soft shaly blue limestone	0	6
1.	Compact crystalline bluish gray limestone to the bottom of the ditch	1	4

This gives the total amount of rock exposed in "Deep Cut." Whatever may have been uncovered farther down the ditch to the north is now completely concealed. In the comparatively low flat to the northeast, however, the blue marly shale is said to lie but a few feet below the surface, and has frequently been reached in laying tile. Mr. Smith, who owns the land along the east side of the railroad here, a few years ago dug a well along the northern slope of the ridge. It penetrated five feet of sand and gravel, then entered the blue marly shale.

The fauna of the Prout limestone is not abundant nor is it well preserved, but it carries among its more plentiful species, forms which are common to the Delaware limestone, and this probably accounts for Newberry's erroneous statement that "At Belleville the Huron shale may be seen resting directly upon the Corniferous limestone."[1]

Plum Creek.—Probably the best outcrop of the upper portion of the Olentangy formation is that to be found along Plum Creek (see Plates VIII and IX) a mile and a quarter east of "Deep Cut" and about two miles northeast of Prout station. Here the rocks have a thirteen degree dip to the south, and are covered with but a few feet of drift. The upper part of the following section is exposed on lands owned by E. D. and T. C. Fox and by Mr. Kellar, while the lowest part of the soft blue shale may be seen across the road to the north.

Huron shale.

		Ft.	In.
9.	Black bituminous shale	4	0

Olentangy formation.

8.	The Prout limestone. Very hard silicious blue limestone with a layer of cherty pyrite at the top. Silicified Corals and Crinoid stems are the most abundant fossils	8	10
7.	Covered interval	6	0
6.	Layer of fossiliferous soft blue limestone	0	6
5.	Fossiliferous soft argillaceous blue shale	3	6
4.	Layer of quite hard fossiliferous blue limestone	0	6
3.	Fossiliferous soft blue shale	5	0
2.	Five inches of limestone overlying four inches of shaly limestone, both fossiliferous, and the latter very fossiliferous	0	9

[1] *Loc. cit.*, p. 190.

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Weathered banks of Olentangy shale along Plum Creek near Sandusky. The illustration shows blocks of limestone, similar to those shown in Plate V, weathering out of the soft blue shales. These limestones contain some well preserved fossils.

(PHOTO BY F. CARNEY.)

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	Ft.	In.
1. Soft argillaceous blue shale. This portion contains occasional harder nodules or layers of nodules which approach in appearance the flat limestone concretions of the sections at Delaware. While a few fossils were found in it, probably the great body of this marly shale is as barren as its southern representative.....	15	6

The following is the fauna collected here:

	Horizon.
Favosites sp.	8
Zaphrentis sp.	8
Cystodictya sp.	4
Fenestella sp.	8
Hederella canadensis Nicholson	6
Monotrypa tenuis (?) Hall	6
Trematopora sp.	4, 6
Amboccelia umbonata (Conrad)	2
Athyris spiriferoides (Eaton)	1
Atrypa reticularis (Linnæus)	8
Chonetes deflectus Hall	2, 3, 4, 5, 6
Chonetes setigerus (?) (Hall)	5
Crania crenistriata Hall	5
Leiorhynchus kelloggi Hall	2, 4, 5, 6
Leiorhynchus laura (?) (Billings)	4, 6
Leiorhynchus sp.	1
Spirifer pennatus (Atwater)	4, 5
Spirifer sp.	8
Stropheodonta demissa (Conrad)	2, 6
Stropheodonta hemispherica Hall	6
Stropheodonta perplana (Conrad)	8
Actinopteria boydi (Conrad)	6
Actinopteria sp.	4
Aviculopecten cleon (?) Hall	6
Cypricardina indenta (?) Conrad	2
Glyptocardia speciosa Hall	2
Grammysia arcuata (Conrad)	2
Grammysia bellatula Hall	2
Grammysia bisulcata (Conrad)	2
Leiopteria rafinesquii Hall	6
Modiomorpha subalata (Conrad)	2
Modiomorpha sp.	6
Nuculites triqueter Conrad	2
Pholidella sp.	2
Pterinea flabellum (Conrad)	6
Schizodus appressus (Conrad)	2
Sphenotus cuneatus (Conrad)	2
Bellerophon lyra Hall	2
Bellerophon sp.	2
Cyrtonella mitella Hall	6
Platyceras erectum (Hall)	4

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	Horizon.
Pleurotomaria rotalia Hall	2
Styliola fissurella Hall	5
Orthoceras sp.	2
Barchilina sp.	2
Bollia sp.	2
Bythocypris indianensis (?) Ulrich	3, 5, 6
Bythocypris cf. punctatus Ulrich	2, 6
Phacops rana (Green)	2, 4, 6

At Slate Cut, along the Lake Shore and Michigan Southern Railroad, four miles east-southeast of Sandusky, the Prout member of the Olentangy is nicely exposed with the overlying Huron shale. This is probably the best place to observe the contact between these formations, but the blue shale underlying the limestone is not exposed here.

Wilmer.—The Baltimore and Ohio station called Wilmer is located about four miles south of Sandusky. It is the switch which runs in to the old Casparis quarry. The pit is now nearly filled with water, only eight and one-half feet of Delaware limestone rising above the water, but it is said to have been worked to a depth of twenty-five feet. Six feet below the top of the section here is a layer which is filled with *Cystiphyllum vesiculosum*, and thus recalls the similar layer in the France quarry at Bloomville. From the eight and one-half feet, not covered by water, the following species were collected.

Cystiphyllum vesiculosum Goldfuss
Favosites sp.
Stromatopora ponderosa Nicholson
Cystodictya sp.
Camarotœchia sappho (?) Hall
Chonetes deflectus (?) Hall
Chonetes mucronatus (?) Hall
Chonetes sp.
Eunella lincklæni Hall
Orthothetes pandora (Billings)
Pholidostrophia iowaensis (Owen)
Productella spinulicosta Hall
Spirifer audaculus macronotus Hall
Spirifer macrus (?) Hall
Spirifer sp.
Stropheodonta concava Hall
Stropheodonta demissa (Conrad)
Stropheodonta hemispherica Hall
Stropheodonta perplana (Conrad)
Aviculopecten exactus (?) Hall
Aviculopecten princeps (Conrad)
Aviculopecten sp.
Conocardium cuneus (Conrad)
Paracyclas elliptica Hall
Bellerophon pelops (?) Hall

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The Prout limestone member of the Olentangy shale outcropping along Plum Creek. The rocks dip south at an angle of 13° and hence the Huron shale comes in at the fence just above.

(PHOTO BY F. CARNEY.)

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Platyceras carinatum Hall
Platyceras dumosum (?) Conrad
Pleurotomaria sp.
Gyroceras sp.
Orthoceras eriensis (?) Hall
Orthoceras sp.
Proetus sp.

The lower layers of the quarry are said to be about two feet thick and practically unfossiliferous. This item, together with the layer containing *Cystiphyllum vesiculosum*, serves to tie this outcrop to those next to be discussed, and which stratigraphically extend well towards the top of the formation.

Soldiers' Home.—The State Soldiers and Sailors' Home is located about three-quarters of a mile south of the city limits of Sandusky. The limestone here is practically at the surface, and rock has been taken out at several localities. Two of these are now the sites of active quarrying, and both show a similar section in an impure blue limestone, which, when first broken, has a brown or bluish brown color and a strong petroleum odor. The stone usually has an earthy texture, with films of bituminous matter between beds. There is an occasional band of bluish white chert which contains some Bryozoans, but, in general, chert is extremely rare. These quarries produce a large amount of the beautiful blue building stone for which Sandusky is noted, and in addition, a great quantity of crushed rock.

Just across the road from the south corner of the grounds of the Soldiers' Home, William Hendrickson is operating a quarry with the following section:

		Ft.	In.
6.	Drift	2	0
	Delaware limestone.		
5.	Thin bedded fossiliferous blue limestone	5	6
4.	Layers of blue limestone containing many specimens of *Cystiphyllum vesiculosum* associated with *Favosites hemisphericus, Heliophyllum halli,* etc	0	6
3.	More or less irregular layers of almost unfossiliferous blue limestone	5	0
2.	Two to ten-inch layers of sparingly fossiliferous blue limestone, containing some organic matter Between layers are Crinoidal shale partings with numerous trails	6	3
1.	Two massive layers of blue limestone, with some chert between. Sometimes these layers split up into several. The bottom of the quarry is blue limestone	3	6

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The following fauna may be found in this quarry:

	Horizon.
Cystiphyllum vesiculosum Goldfuss	4
Diphyphyllum sp.	4
Favosites hemisphericus (Troost)	4
Heliophyllum halli Edwards and Haime	4
Stromatopora sp.	5
Cystodictya gilberti (Meek)	1, 2, 3
Fenestella sp.	1
Monotrypa sp.	3
Atrypa reticularis (Linnæus)	2, 5
Chonetes deflectus Hall	1, 2
Leiorhynchus limitare (Vanuxem)	1, 2
Lingula manni Hall	1
Martinia maia (Billings)	1, 2
Pholidostrophia iowaensis (Owen)	5
Stropheodonta demissa (Conrad)	1, 5
Stropheodonta hemispherica Hall	5
Stropheodonta sp.	5
Conocardium cuneus (Conrad)	5
Cypricardella tenuistriata (Hall)	2
Glyptodesma erectum (Conrad)	1
Nyassa arguta (?) Hall	2
Paracyclas elliptica Hall	2, 5
Platyceras erectum (Hall)	1, 2
Pleurotomaria sp.	5
Tentaculites scalariformis Hall	1

In addition to this small collection of invertebrates, fish teeth are common, while the skulls and jaws of *Onychodus sigmoides* are occasionally found. In the Wagner quarry No. 1, near the east corner of the Soldiers' Home, the Delaware limestone has been opened to a depth of twenty-five feet, and is in every way practically a duplicate of the above section and fauna. In addition to the above species, however, a few other forms were found here. Among these are: *Ambocoelia umbonata, Camarospira eucharis, Chonetes scitulus, Chonostrophia reversa, Stropheodonta concava, Palaeoneilo* (?) *sanduskiensis, Phacops rana,* etc., while traces of the layer containing *Cystiphyllum vesiculosum* can also be found.

Sandusky.—The city of Sandusky is perhaps the most famous Devonian limestone locality in the state, and, taken in connection with the outcrops at Marblehead and on the islands, it well deserves this distinction. In excavating for the basements of residences and other buildings of the city, and in laying water mains and building sewers, it is necessary often to blast away the rock, and such excavations have much the appearance of a newly opened quarry. The city is literally "founded upon a rock."

The vicinity of Hancock street and Sycamore line,[1] in the southeastern part of the city, has long been the scene of the quarrying in-

[1]Prosser, Charles S., *Jour. Geol.*, Vol. XIII, 1905, pp. 433, 434.

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dustry. At this place a half dozen or so different quarries have been located, but at the present time only two are being operated, and of these the Wagner quarry No. 2 is the larger, and, for the present purpose, the more interesting.

The following is a section of the rocks in the Wagner No. 2, or old Schoepfle quarry.[1]

Delaware limestone.

		Ft.	In.
13.	(This portion is exposed across the street to the south of the quarry and in an old pit now used as a city dump.) Shaly blue to brown limestone with some chert at the base	3	0
12.	Two layers of somewhat massive Crinoidal blue limestone. About three inches of the lower layer is left in spots on the top layer of the Wagner quarry No. 2	2	0

Columbus limestone.

11.	"Bone-bed," poorly defined, but traces of it found on both sides of Hancock street	..	..
10.	Crinoidal blue limestone containing many Corals	3	8
9.	Massive crystalline blue limestone	4	0
8.	Blue limestone showing many Crinoid fragments where weathered	2	6
7.	Several layers of blue limestone containing a great abundance of *Tentaculites scalariformis.* These are more conspicuous in the bedding planes	1	6
6.	Blue limestone separated from the layer below by a prominent iron bearing stylolitic contact	0	6
5.	Massive blue limestone separating into several layers. A *Spirifer acuminatus* horizon occurs three feet above the bottom of this zone	3	8
4.	Very fossiliferous blue limestone bearing a *Spirifer acuminatus* horizon at the top. (One of the wave-marked surfaces, common around Sandusky, is found in the middle of this bed)	1	0
3.	An irregular layer of hard compact bluish gray limestone forming somewhat of a boundary line between the blue and the gray to brown limestone and not distinctly separated from the layer below. (This same layer occurs in the Olemacher quarry at Marblehead)	0	3

[1]See also Swartz, Charles K., *Op. cit.*, p. 58; also Prosser, C. S., *Jour. Geol.*, Vol. XIII, 1905, pp. 436-438.

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	Ft.	In.
2. Gray to brown limestone with the fossils more or less in strips or pockets.....	2	0
1. Very massive grayish brown limestone showing no bedding, but rudely banded. The fossils are in strips or pockets, as in the layer above. The rock has a strong odor of petroleum but where long exposed so that this escapes it, assumes its usual gray color.....	8	0

The following fossils are among those to be seen in this section:

	Horizon.
Calcisphæra robusta Williamson.....	1, 2
Cystiphyllum vesiculosum (?) Goldfuss.....	5, 8, 9, 10
Diphyphyllum sp.....	2, 4
Favosites emmonsi Rominger.....	1
Favosites hemisphericus (Troost).....	1, 2, 3, 5, 10
Hadrophyllum d'orbignyi Edwards and Haime.....	12
Stylastrea anna Whitfield.....	2
Syringopora sp.	5
Zaphrentis cornicula Edwards and Haime.....	1, 2
Zaphrentis gigantea (?) Rafinesque.....	1, 4
Zaphrentis sp.	5
Megistocrinus spinulosus Lyon.....	9
Nucleocrinus verneuili (Troost)	10
Coscinium striatum Hall and Simpson.....	9
Cystodictya gilberti (Meek).....	1, 2, 4, 5, 9
Fenestella sp.	1, 2, 4, 5, 7, 8, 9
Lichenalia sp.	9
Monotrypa sp.	9
Atrypa reticularis (Linnæus).....	1, 2, 4, 5, 7, 8, 9
Atrypa spinosa Hall.....	2, 4, 5, 9
Chonetes mucronatus Hall.....	1, 7, 8, 9
Cyrtina hamiltonensis Hall.....	5, 10
Delthyris consobrina (d'Orbigny).....	12
Leptæna rhomboidalis (Wilckens)	4, 7, 10, 12
Martinia maia (Billings).....	2
Pholidops patina Hall and Clarke.....	4, 8
Productella spinulicosta Hall.....	5
Rhipidomella vanuxemi Hall.....	4, 7, 8, 9, 10, 13
Schizophoria propinque Hall.....	5, 7
Spirifer acuminatus (Conrad).....	4, 5
Spirifer duodenarius (Hall).....	10
Spirifer macrus Hall.....	7, 10
Spirifer varicosus Hall.....	10
Spirifer sp.	8
Stropheodonta demissa (Conrad).....	1, 2, 3, 4, 5, 7, 10
Stropheodonta hemispherica Hall.....	1, 2, 4, 5, 7, 10
Stropheodonta patersoni Hall.....	5
Stropheodonta perplana (Conrad).....	1, 4, 5, 10
Aviculopecten princeps (Conrad).....	10

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	Horizon.
Paracyclas elliptica Hall	5, 8, 10
Euomphalus decewi Billings	4
Platyceras dumosum Conrad	9
Platyceras erectum (Hall)	13
Pleurotomaria sp.	4
Tentaculites scalariformis Hall	1, 7, 8
Dalmanites sp.	5
Phacops sp.	5
Proetus sp.	1

This is the section of which the upper part was so long considered to be the equivalent of the section in Campbell's quarry at Delaware, Ohio, and the fauna which led Bownocker to the conclusion that the faunas above and below the "bone-bed" differ less at Sandusky than to the south.[1] Still earlier it formed the basis of Newberry's contention that the "Sandusky limestone," the supposed equivalent of the Delaware limestone, is of Corniferous age, and led him to the erroneous conclusion that the Delaware limestone does not carry a Hamilton fauna. The section is, as we know now, the upper portion of the Columbus limestone and the fauna characteristic of that portion of the formation. In color and texture, however, the rock resembles that of the overlying formation so closely that the deception was a very natural one, especially since the present quarries at the Soldiers' Home had not then been opened, nor were those in the city worked to any considerable depth.[2] Another section which is poorly exposed, but worth mention perhaps, since it duplicates the one just given, is that on Mills Creek in the southwestern part of the city. The section, beginning at the highway arch just south of the Lake Shore and Michigan Southern Railroad tracks, extends along the creek to the south through the O'Donald quarry, up a small westerly branch and into the Wagner Stone Company's quarry No. 4, a little more than a mile south of the city limits.

		Ft.	In.
14.	Soil	0	6
	Delaware limestone.		
13.	Weathered blue to brown limestone	2	4
12.	Uniform blue limestone having a massive appearance, but breaking up into three to six-inch layers	7	6
11	Even bedded blue limestone in four to six-inch layers with some nodules of chert at the top	2	6
10.	Layer of blue limestone containing much white chert	0	3

[1]Bownocker, J. A., *Bull. Sci. Lab. Den. Univ.*, Vol. XI, 1898, p. 31.
[2]*Idem*, p. 29.

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		Ft.	In.
9.	Compact blue limestone in layers about six inches thick	4	0
8.	Interval, mostly covered, from near the city limits to the base of the Wagner Stone Company's quarry No. 4	10	0

Columbus limestone.

7.	Very fossiliferous hard crystalline blue limestone containing a good many Corals and some fish teeth at the top shown just south of the city limits	3	6
6.	Several layers of a massive blue limestone, not very fossiliferous	4	0
5.	Rather thin bedded blue limestone, the lower layers containing a great many specimens of *Tentaculites scalariformis*	5	0
4.	Quite fossiliferous blue limestone containing a horizon of *Spirifer acuminatus* at the top	3	6
3.	Massive gray to bluish gray limestone	2	0
2.	Very fossiliferous gray limestone	1	6
1.	Fairly massive crystalline gray limestone, quite fossiliferous. This extends to the bottom of the creek at the highway arch	2	0

The O'Donald quarry, which is located in the bed of the creek and within the city limits, is now abandoned, but the Wagner quarry No. 4 is a new plant producing a great quantity of crushed rock, and hence its section is constantly improving.

The following fauna may be found in this section:

	Horizon.
Calcisphæra robusta Williamson	1, 2
Cystiphyllum vesiculosum Goldfuss	7
Favosites hemisphericus (Troost)	1, 5
Stylastrea anna Whitfield	1
Syringopora sp.	4
Zaphrentis cornicula Edwards and Haime	1
Zaphrentis prolifica Billings	4
Zaphrentis sp.	1, 4, 5, 6, 7
Coscinium striatum Hall and Whitfield	4
Cystodictya gilberti (Meek)	2
Cystodictya sp.	10, 12
Fenestella sp.	2, 3, 4, 5, 7, 12
Orthonota sp.	7
Atrypa reticularis (Linnæus)	3, 4, 5, 6, 7
Atrypa spinosa Hall	4
Camarotœchia sp.	6
Chonetes deflectus Hall	9, 10, 11, 12
Chonetes mucronatus Hall	3, 4

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	Horizon.
Chonetes sp.	3, 4, 5, 7
Chonostrophia reversa (Whitfield)	10
Eunella sp.	7
Leptæna rhomboidalis (Wilckens)	4, 5, 7, 9, 10, 11, 12, 13
Martinia maia (Billings)	12
Orthothetes pandora (Billings)	3
Pentamerella arata (Conrad)	6, 7
Pholidops patina Hall and Clarke	2
Reticularia fimbriata (Conrad)	7
Rhipidomella vanuxemi Hall	3, 4, 6, 7
Spirifer acuminatus (Conrad)	4
Spirifer duodenarius (Hall)	7
Spirifer macrus Hall	3
Spirifer manni Hall	4
Spirifer sp.	2, 3, 4, 5, 6
Stropheodonta demissa (Conrad)	1, 2, 3, 4, 5, 6, 7
Stropheodonta hemispherica Hall	1, 4, 5, 6, 7
Stropheodonta perplana (Conrad)	1, 2, 4, 5, 6
Aviculopecten princeps (Conrad)	5, 12
Aviculopecten sp.	5
Glyptodesma erectum (Conrad)	10, 12
Paracyclas elliptica Hall	4, 5, 7, 12
Dentalium sp.	7
Euomphalus decewi Billings	7
Platyceras carinatum Hall	7
Platyceras dumosum Conrad	4
Platyceras erectum (Hall)	10
Tentaculites scalariformis Hall	1, 3, 4, 5
Gyroceras sp.	4
Phacops sp.	6, 9, 10
Proetus rowii Green	7
Proetus sp	2, 7, 12

Aside from the similarity of the Columbus limestone portion of this section and its fauna to that just given for the Wagner quarry No. 2, the lowest zone is in rock which is very similar in its fauna and lithological appearance to the top layers of the James quarry at Marblehead. Whether the horizon of the Sandusky and Marblehead localities is identical cannot be certainly established, since the fauna depended upon is that of a considerable portion of the Columbus limestone at Marblehead. The error in considering the localities as reaching the same horizon is not a serious one, however, and probably does not exceed a few feet. A more exact means of correlating the sections of Columbus limestone of this vicinity will be pointed out later.

Venice.—This is the first station west of Sandusky along the Lake Shore and Michigan Southern Railroad. The section in question for this locality lies a mile and three-quarters south of Venice, and about two and one-half miles southwest of the main portion of Sandusky. It is at the end of the Venice switch and has usually been called the Lake Shore

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Railroad quarry. (See Plate X). Here the "bone-bed" is fairly well shown, and the dividing line between the Columbus and Delaware limestones is evident.[1] The following section was measured in this quarry:

		Ft.	In.
8.	Soil and drift	1	0
	Delaware limestone.		
7.	Blue limestone alternating with layers of gray chert	2	6
6.	Massive and thin bedded crystalline blue limestone. Weathered surface very Crinoidal	3	4
5.	Rather impure blue limestone with a tendency to be shaly	2	0
	Columbus limestone.		
4.	"Bone-bed," not always well defined	..	..
3.	A rather thin bedded compact blue limestone	2	4
2.	A layer made up largely of *Diphyphyllum verneuilanum*	0	4
1.	More or less crystalline to gray limestone and very fossiliferous	7	10

This quarry is at the summit of a low anticline, the axis of which passes north and south just west of the middle of the pit. The similarity of the section to the same horizon at Columbus is most striking, and this is brought out more clearly by the following fauna:

Hadrophyllum d'orbignyi Edwards and Haime	Delaware ls.
Cystodictya sp.	"
Camarotœchia prolifica Hall	"
Camarotœchia tethys (Billings)	"
Chonetes deflectus (?) Hall	"
Chonetes scitulus Hall	"
Delthyris consobrina (d'Orbignyi)	"
Leptæna rhomboidalis (Wilckens)	"
Leiorhynchus limitare (?) (Vanuxem)	"
Orbiculoidea minuta (Hall)	"
Orthothetes pandora (Billings)	"
Stropheodonta demissa (Conrad)	"
Glyptodesma erectum (Conrad)	"
Grammysia bisulcata (Conrad)	"
Bellerophon sp.	"
Platyceras erectum (Hall)	"
Platyceras sp.	"
Tentaculites scalariformis Hall	"

[1]See Prosser, Charles S., *Jour. Geol.*, Vol. XIII, 1905, pp. 434-436, and half-tone on p. 440, which is shown in Plate X.

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The contact between the Columbus and Delaware limestones in the Lake Shore Railroad quarry south of Venice. The "bone-bed" is shown at the point where the hammer and collecting bag are placed.
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Cystiphyllum vesiculosum (?) Goldfuss	Columbus ls.
Diphyphyllum verneuilanum (Edwards and Haime)	"
Favosites hemisphericus (Troost)	"
Zaphrentis cornicula Edwards and Haime	"
Zaphrentis sp.	"
Stromatopora ponderosa Nicholson	"
Nucleocrinus verneuili (Troost)	"
Cystodictya gilberti (Meek)	"
Fenestella sp.	"
Stictopora sp.	"
Atrypa reticularis (Linnæus)	"
Camarotœchia tethys (Billings)	"
Chonetes mucronatus Hall	"
Chonetes sp.	"
Cyrtina crassa Hall	"
Eunella sp.	"
Leptæna rhomboidalis (Wilckens)	"
Pentamerella arata (Conrad)	"
Pholidostrophia iowaensis (Owen)	"
Productella spinulicosta Hall	"
Rhipdomella venuxemi Hall	"
Spirifer acuminatus (Conrad)	"
Spirifer duodenarius (Hall)	"
Spirifer manni Hall	"
Stropheodonta demissa (Conrad)	"
Stropheodonta hemispherica Hall	"
Stropheodonta perplana (Conrad)	"
Paracyclas elliptica Hall	"
Euomphalus decewi Billings	"
Platyceras carinatum Hall	"
Platyceras rictum Hall	"
Tentaculites scalariformis Hall	"
Proetus crassimarginatus Hall	"
Proetus welleri n. sp	"

Johnson's Island.—This island lies in Sandusky Bay, about three miles north of the city of Sandusky and about two miles west of Cedar Point. On the southeast side of the island quarrying has been quite extensive, and together with the cliff three hundred feet to the north has uncovered the following section:

Columbus limestone.

		Ft.	In.
10.	Massive gray limestone shown in the cliff at the east end of the old fortification. Among the abundant fauna is *Calcisphæra robusta* and *Spirifer gregarius*	16	0
9.	Covered interval	10	8
8.	Thin bedded gray or brownish gray limestone quite fossiliferous	5	0
7.	A massive layer of grayish brown limestone	1	6

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		Ft.	In.
6.	A massive layer of gray or brownish gray limestone sparingly fossiliferous.....	5	0
5.	A massive layer of grayish brown limestone, very fossiliferous and with an uneven contact with the underlying formation. *Spirifer gregarius* is an abundant fossil	2	4

Monroe limestone.

4.	Rather thick layer of banded brown limestone	4	9
3.	A layer made up almost entirely of *Stromatopora* sp. and a few Corals. The rock has a dark bluish or purplish brown color	0	9
2.	Hard layers of gray limestone conspicuously banded	0	9
1.	Grayish brown banded limestone in massive layers to the bottom of the quarry. Near the middle it contains *Meristella* sp.....	6	6

The following are only a few of the species abundant in the fauna:

	Horizon.
Calcisphæra robusta Williamson.....	10
Diphyphyllum verneuilanum (Edwards and Haime)..	8
Favosites hemisphericus (Troost).....	5, 8
Favosites limitaris (?) Rominger.....	5
Zaphrentis cornicula Edwards and Haime.....	8
Stromatopora ponderosa Nicholson.....	8
Cystodictya gilberti (Meek).....	5, 8
Fenestella sp.	5
Monotrypa tenuis (Hall).....	5
Polypora robusta (Hall).....	8
Atrypa reticularis (Linnæus).....	5, 8
Chonetes mucronatus Hall.....	8
Crania crenistriata Hall.....	5
Cryptonella lens Hall.....	8
Pholidostrophia iowaensis (Owen).....	5
Rhipodomella vanuxemi Hall.....	5
Spirifer gregarius Clapp.....	5, 8
Spirifer sp.	8
Strophеodonta demissa (Conrad).....	5, 8
Strophеodonta hemispherica Hall.....	5, 8
Strophonella ampla Hall.....	5
Conocardium cuneus (Conrad).....	5, 8
Platyceras erectum (Hall).....	10
Pleurotomaria lucina Hall.....	5
Phacops cristata Hall.....	5, 8

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Marblehead.[1]—The quarries at Marblehead, near the east end of the peninsula north of Sandusky Bay, are the largest of the quarries in the Devonian limestone within the state. In each of several quarries many acres have been worked to a depth of twenty or thirty feet. Lime is still being burned here, but the production of crushed rock has grown rapidly and is now by far the more important industry.

The Olemacher quarry is located at the south side and near the east end of the peninsula. While its lime-kilns and crusher are now abandoned, its section is still fresh and most interesting, since it forms a connecting link between the Kelley's Island quarries and those in Sandusky. The following is a section of the rocks here.

Columbus limestone.

		Ft.	In.
9.	Rather thin bedded bluish gray limestone, containing *Spirifer acuminatus* near the base	3	8
8.	Irregular layer of hard compact bluish gray limestone, not always separated from the layer below. (This is the equivalent of No. 3 in the section of the Wagner quarry No. 2)	0	3
7.	Usually thin bedded gray or slightly bluish limestone, quite fossiliferous. The fossils are in streaks or pockets and the rock is not always clearly separated from that below	2	0
6.	Massive gray limestone rudely banded and very fossiliferous, the fossils occurring in streaks and pockets	4	8
5.	Brown to grayish brown limestone, quite fossiliferous	6	10
4.	Massive brown to grayish brown rock which is known to the quarrymen as "bottom rock," probably because it was formerly the last course that was taken out	7	6
3.	Layers of white chalky chert nodules	0	3
2.	Brown limestone with no chert and few fossils	1	6
1.	Soft gray shale in the bottom of the quarry	0	4

The following is the fauna collected at this point:

	Horizon.
Calcisphæra robusta Williamson	5, 6, 7
Cystiphyllum vesiculosum Goldfuss	4
Favosites hemisphericus (Troost)	4, 5, 6, 9
Pleurodictyum problematicum Goldfuss	6
Stylastrea anna Whitfield	5, 6, 7

[1]See also Swartz, Charles K., *Op. cit.*, p. 57.

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	Horizon.
Zaphrentis cornicula Edwards and Haime	4, 6
Stromatopora ponderosa Nicholson	4
Cystodictya gilberti (Meek)	4, 5, 6, 7, 8
Fenestella sp.	6, 7, 8
Monotrypa tenuis (Hall)	4, 7
Athyris vittata indianaensis n. var	7
Atrypa reticularis (Linnæus)	4, 6, 7, 8, 9
Atrypa spinosa Hall	9
Camarotœchia carolina Hall	9
Camarotœchia tethys (Billings)	8, 9
Chonetes mucronatus Hall	4, 5, 6, 7, 8
Cyrtina hamiltonensis Hall	9
Eunella lincklæni Hall	6
Pentamerella arata (Conrad)	9
Pholidops patina Hall and Clarke	5, 7
Rhipidomella vanuxemi Hall	9
Schizophoria propinque Hall	4, 8
Spirifer acuminatus (Conrad)	9
Spirifer varicosus Hall	7, 8
Spirifer sp.	4, 5, 9
Stropheodonta demissa (Conrad)	4, 5, 6, 7, 9
Stropheodonta hemispherica Hall	4, 5, 6, 7, 9
Stropheodonta perplana (Conrad)	6, 7, 9
Conocardium cuneus (Conrad)	6
Nucula sp.	8
Paracyclas elliptica Hall	9
Callonema lichas (Hall)	9
Euomphalus decewi Billings	6
Loxonema sp.	7
Tentaculites scalariformis Hall	5
Phacops sp.	5, 7, 9
Proetus sp.	9

The James quarry, which is one of the larger and likewise of the older quarries, is located just south of the railroad station at Marblehead. Its section, which is essentially that of all the other nearby quarries, together with that of the rocks at the lake shore just below, is as follows:

Columbus limestone.

		Ft.	In.
12.	Fossiliferous gray limestone to the top of the quarry on the west side near the cemetery and ball grounds	3	0
11.	Fossiliferous gray limestone with *Spirifer acuminatus* occurring in great numbers at the top	10	6
10.	A granular light gray limestone which is especially full of *Calcisphæra robusta*	1	0
8.	Thin bedded fossiliferous gray limestones. Layers irregular and about two or three inches thick	5	6

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	Ft.	In.
8. "Bottom rock." Gray to grayish brown limestone usually occurring as one massive layer, but at some places splitting into several or a number of layers. Very fossiliferous with Corals especially conspicuous at the top	8	6
7. Fossiliferous gray limestone with some chalky white chert in the upper part. This layer forms the base of the north part of the quarry	1	9
6. Soft gray shale. (This shale is the equivalent of that forming the bottom of the Olemacher quarry)	0	4
5. Layer of gray limestone with very little or no chert	0	10
4 Hard cherty gray limestone	2	3
3. Covered interval	12	0
2. Massive gray limestone containing an abundant fauna. This rock is exposed along the lake just east of the United States Life Saving Station	5	6

Monroe limestone.

1. Fossiliferous compact drab limestone to lake level	2	0

The following fauna was collected from this section:

	Horizon.
Calcisphæra robusta Williamson	2, 7, 10, 11
Cyathophyllum rugosum Hall	11
Diphyphyllum verneuilanum (Edwards and Haime)	11
Diphyphyllum sp.	11
Favosites hemisphericus (Troost)	2, 8, 9, 10, 11
Syringopora tabulata Edwards and Haime	11
Zaphrentis cornicula Edwards and Haime	2, 7, 10, 11
Zaphrentis sp.	2, 4, 8, 9
Stromatopora ponderosa Nicholson	11
Stromatopora sp	2
Cystodictya gilberti (Meek)	10, 11
Cystodictya sp.	10
Fenestella sp.	2
Monotrypa tenuis (Hall)	2, 11
Atrypa reticularis (Linnæus)	2, 8, 9, 10, 11
Chonetus mucronatus Hall	2, 5, 10, 11
Chonetus sp.	2, 8
Cyrtina hamiltonensis Hall	2
Delthyris raricosta Conrad	2
Leptæna rhomboidalis (Wilckens)	2
Nucleospira concinna Hall	2, 10, 11
Orthothetes pandora (Billings)	10

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	Horizon.
Rhipidomella vanuxemi Hall	2, 8, 9, 11
Schizophoria propinque Hall	10, 11
Spirifer acuminatus (Conrad)	11
Spirifer divaricatus Hall	2
Spirifer gregarius Clapp	2
Spirifer manni Hall	10, 11
Spirifer varicosus Hall	11
Spirifer sp.	2, 10, 11
Stropheodonta concava Hall	10, 11
Stropheodonta demissa (Conrad)	2, 9, 10, 11
Stropheodonta hemispherica Hall	2, 5, 8, 9, 10, 11
Stropheodonta inæquiradiata Hall	2, 11
Stropheodonta perplana (Conrad)	2, 7, 10, 11
Actinopteria boydi (Conrad)	10
Conocardium cuneus (Conrad)	2, 11
Modiomorpha concentrica (Conrad)	11
Paracyclas elliptica Hall	10, 11
Bellerophon pelops Hall	11
Callonema lichas (Hall)	11
Euomphalus decewi Billings	11
Loxonema robustum Hall	11
Loxonema sp.	11
Palæotrochus kearneyi (Hall)	2
Platyceras carinatum Hall	10, 11
Platystoma sp.	10
Trochonema meekanum Miller	10
Tentaculites scalariformis Hall	10
Gyroceras sp.	11
Orthoceras sp.	10
Phacops cristata Hall	2
Phacops sp.	10

Kelley's Island.—This famous island lies five miles off Marblehead and twelve miles north of Sandusky. Its quarries have long been known to science because of the remarkable grooves which are so nicely shown in the glaciated surface of the Columbus limestone. Lime, heavy building stone and crushed rock are produced here on a large scale; the latter, however, is beginning to assume the greater importance. In the South Side quarry the following section is shown: (See Plates XI and XII).

		Ft.	In.
14.	Soil and drift	2	0
	Columbus limestone.		
13.	Thin bedded bluish gray limestone	1	6
12.	Thin bedded bluish gray limestone with *Spirifer acuminatus* occurring occasionally at the top	3	0
11.	Thin bedded bluish gray limestone with a well developed *Spirifer acuminatus* horizon at the top	5	6

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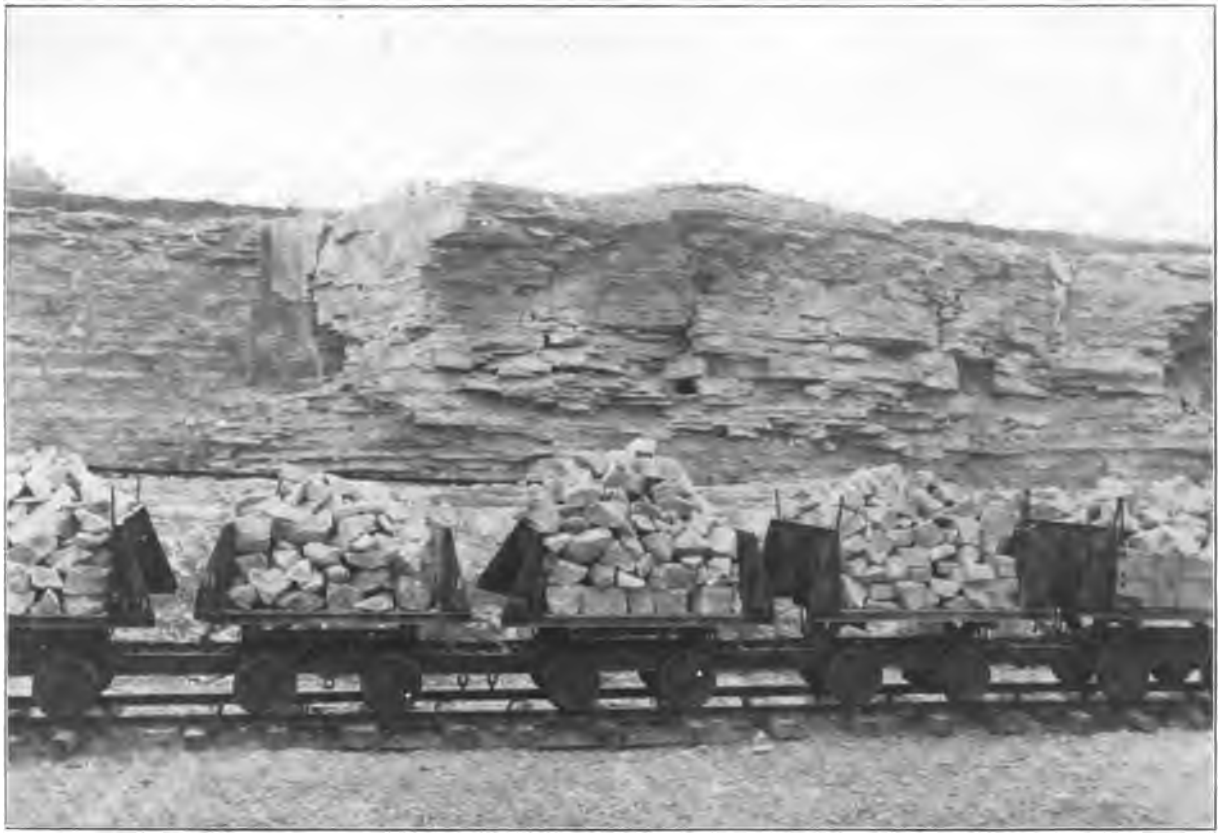

The thin bedded upper portion of the Columbus limestone in the west side of the South Side quarry, Kelley's Island. The massive rock just back of the stone cars is "bottom rock."

(PHOTO BY C. R. STAUFFER.)

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	Ft.	In.
10. Rather thin bedded very fossiliferous gray limestone. *Favosites hemisphericus* especially conspicuous. A horizon of *Spirifer acuminatus* at the top	5	0
9. Very fossiliferous gray limestone in three to five-inch layers. A *Spirifer acuminatus* horizon at the top	7	10
8. "Bottom Rock." A massive layer of grayish brown limestone, but where much weathered it splits up into thinner beds	9	0
7. Grayish brown limestone with much gray to white chert intermixed	3	6
6. Compact brown limestone with no chert	1	0
5. Parting of gray to light brown shale. (This is the same shaly band that forms the bottom of the Olemacher section)	0	3
4. Massive brown limestone. The surface under the shale is rather uneven and is marked with vermicular trails	4	0
3. Massive gray to grayish brown limestone with few or no distinct bedding planes. Fossils not abundant	12	8
2. A very fossiliferous crystalline gray limestone	4	0
Monroe limestone.		
1. Massive compact dark brown banded limestone carrying a Silurian fauna	2	6

The physical break between the Monroe and the Columbus limestones is not great, although the rock texture is somewhat different in the two. Blocks a foot thick may be collected, in the top of which is a rich Devonian fauna, while in the bottom the Silurian fauna is almost equally abundant. The faunal break is thus sharp and decided, and the possibility of mistaking the contact remote, although the two formations, notwithstanding the unconformity, are completely welded together.

The following fauna was collected in this quarry.

	Horizon.
Calcisphæra robusta Williamson	8, 9
Cystiphyllum sulcatum (?) Billings	7
Cystiphyllum sp.	7
Diphyphyllum bellis (?) Davis	2
Diphyphyllum stramineum Billings	2
Diphyphyllum strictum (Edwards and Haime)	8
Diphyphyllum sp.	7, 8, 9
Favosites emmonsi Rominger	2
Favosites hemisphericus (Troost)	2, 7, 8, 9
Favosites pleurodictyoides Nicholson	8, 9
Pleurodictyum problematicum Goldfuss	9
Syringopora tabulata Edwards and Haime	2, 10
Zaphrentis cornicula Edwards and Haime	2, 7, 8, 9

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	Horizon.
Zaphrentis gigantea Rafinesque	9
Zaphrentis sp.	8, 11
Stromatopora ponderosa Nicholson	2
Stromatopora sp.	8
Syringostroma columnaris Nicholson	10
Syringostroma densa Nicholson	2
Dolatocrinus sp.	2
Coscinium striatum Hall and Simpson	9
Cystodictya gilberti (Meek)	7, 8, 9, 10
Fenestella sp.	2, 8, 9
Monotrypa tenuis Hall	2, 9
Athyris vittata indianaensis n. var	9, 12
Atrypa reticularis (Linnæus)	2, 8, 9, 10
Camarotœchia tethys (Billings)	8, 10
Chonetes hemisphericus Hall	10
Chonetes mucronatus Hall	2, 7, 8, 9
Chonetes sp.	7, 8, 9, 10, 11
Crania crenistriata Hall	9
Cyrtina hamiltonensis Hall	10, 11
Eunella lincklæni Hall	2, 7
Leptæna rhomboidalis (Wilckens)	8, 9, 10
Orthothetes pandora Billings	8, 9, 10
Productella spinulicosta Hall	8, 10
Pholidops patina Hall and Clarke	9, 10
Rhipidomella vanuxemi Hall	2, 5, 6, 7
Schizophoria propinque Hall	2, 9, 10
Spirifer acuminatus (Conrad)	9, 10, 11, 12
Spirifer gregarius Clapp	2, 9
Spirifer fornacula (?) Hall	10
Spirifer macrus Hall	10
Spirifer sp.	8, 12
Stropheodonta concava Hall	8
Stropheodonta demissa (Conrad)	7, 8, 9, 10
Stropheodonta hemispherica Hall	2, 7, 8, 9, 10
Stropheodonta inæquiradiata (?) Hall	8
Stropheodonta perplana (Conrad)	2, 8, 9
Strophonella ampla Hall	2
Actinopteria sp.	10
Aviculopecten cleon (?) Hall	10
Aviculopecten princeps (Conrad)	10
Aviculopecten sp.	9
Conocardium cuneus (Conrad)	2, 10
Paracyclas elliptica Hall	2, 7, 12
Bellerophon pelops (?) Hall	2, 10
Callonema lichas (?) (Hall)	7
Callonema sp.	10
Loxonema sp.	10
Palæotrochus kearneyi (Hall)	2
Platyceras carinatum (?) Hall	10
Platyceras dumosum Conrad	12
Pleurotomaria sp.	7
Gyroceras cyclops Hall	10
Chasmops calypso (?) Hall	10

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The massive portion of the Columbus limestone lying below "bottom rock" in the South Side quarry, Kelley's Island.
(PHOTO BY C. R. STAUFFER.)

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	Horizon.
Coronura diurus (Green)	10
Phacops cristata Hall	11
Proetus sp.	8, 10

The *Spirifer acuminatus* horizons mentioned in the section last given and elsewhere, are conspicuous and fairly well marked, but this fossil is not limited to these horizons. A careful examination of the intervening beds has been rewarded with a few specimens at a number of different localities. Whether it is safe to correlate these horizons here with those of distant sections is rather doubtful.

In the North Side quarry the following section is exposed:

Columbus limestone.

		Ft.	In.
10.	Thin bedded fossiliferous gray limestone, the top layer containing *Spirifer acuminatus* in great numbers	10	8
9.	Very fossiliferous gray limestone somewhat more massive than the layers above	7	6
8.	"Bottom rock." A massive layer of gray to brown limestone. It sometimes shows one or two minor bedding planes but is usually one layer	7	8
7.	Brown limestone with rather soft gray to white chert intermixed	3	9
6.	Brown limestone with no chert	1	0
5.	Thin grayish brown shaly parting	0	3
4.	Massive brown limestone with some chert in three discontinuous layers	4	3
3.	Massive brown limestone somewhat banded and in one or two beds. Its fauna is not so abundant as in the upper part of the section	14	6
2.	Very fossiliferous brown to grayish brown limestone	4	0

Monroe limestone.

1.	Brown limestone carrying a Silurian fauna.	1	0

The following fauna was collected in the upper part of the section at this locality:

	Horizon.
Calcisphæra robusta Williamson	9, 10
Diphyphyllum strictum (Edwards and Haime)	9
Diphyphyllum sp.	8, 10
Favosites hemisphericus (Troost)	8, 9, 10
Favosites pleurodictyoides Nicholson	9, 10
Favosites sp.	10
Zaphrentis cornicula Edwards and Haime	8, 9, 10
Stromatopora ponderosa Nicholson	8, 9
Cystodictya gilberti (Meek)	9, 10

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	Horizon.
Fenestella sp.	10
Monotrypa tenuis (Hall)	9
Athyris vittata indianaensis n. var	10
Atrypa reticularis (Linnæus)	9, 10
Camarotœchia billingsi Hall	10
Camarotœchia tethys (Billings)	10
Camarotœchia sp.	10
Chonetes arcuatus Hall	10
Chonetes hemisphericus Hall	10
Chonetes mucronatus Hall	9, 10
Cyrtina hamiltonensis Hall	10
Leptæna rhomboidalis (Wilckens)	10
Orthothetes pandora (Billings)	10
Pholidops patina Hall and Clarke	10
Productella spinulicosta Hall	10
Rhipodomella vanuxemi Hall	10
Schizophoria propinque Hall	9, 10
Spirifer acuminatus (Conrad)	10
Spirifer gregarius Clapp	10
Spirifer grieri Hall	10
Spirifer varicosus Hall	10
Stropheodonta concava Hall	10
Stropheodonta demissa (Conrad)	9, 10
Stropheodonta hemispherica Hall	7, 9, 10
Stropheodonta perplana (Conrad)	9, 10
Actinopteria sp.	10
Aviculopecten cleon (?) Hall	10
Aviculopecten princeps (Conrad)	10
Conocardium cuneus (Conrad)	10
Modiomorpha concentrica (Conrad)	10
Paracyclas elliptica Hall	10
Sanguinolites (?) sanduskiensis Meek	10
Callonema lichas Hall	10
Euomphalus decewi Billings	10
Loxonema sp.	10
Platyceras carinatum Hall	10
Pleurotomaria lucina (?) Hall	10
Tentaculites scalariformis Hall	9, 10
Coronura diurus (Green)	10
Phacops cristata Hall	9

A short distance to the west of this, at the north lake shore, is another small quarry which was formerly operated in connection with the main part of the North Side quarry. Here the following section is exposed:

Columbus limestone.

	Ft.	In.
3. Massive grayish or light brown limestone, rather porous and containing an abundant fauna, especially in the lower part. The fossils occur generally as molds and casts	14	0

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Monroe limestone.

	Ft.	In.
2. Compact gray to brown limestone containing a Silurian fauna	9	6
1. Hard layer of very compact banded blue or dark gray limestone to the bottom of the quarry. (See the Johnson's Island section)	1	0

The following fauna was collected from No. 3 of the above section:

Calcisphæra robusta Williamson
Diphyphyllum simcoense (Billings)
Favosites hemisphericus (Troost)
Stylastrea anna Whitfield
Syringopora tabulata Nicholson
Zaphrentis cornicula Edwards and Haime
Stromatopora ponderosa Nicholson
Fenestella sp.
Atrypa reticularis (Linnæus)
Atrypa spinosa Hall
Chonetes mucronatus Hall
Cyrtina hamiltonensis Hall
Eunella lincklæni Hall
Leptæna rhomboidalis (Wilckens)
Nucleospira concinna Hall
Reticularia fimbriata (Conrad)
Rhipidomella vanuxemi Hall
Spirifer divaricatus Hall
Spirifer gregarius Clapp
Spirifer macrus Hall
Stropheodonta demissa (Conrad)
Stropheodonta hemispherica Hall
Stropheodonta inæquiradiata Hall
Conocardium cuneus (Conrad)
Paracyclas elliptica Hall
Bellerophon sp.
Loxonema sp.
Palæotrochus kearneyi (Hall)
Platyceras dumosum Conrad
Pleurotomaria sp.
Turbo shumardi Verneuil
Coronura diurus (Green)
Phacops cristata Hall
Proetus crassimarginatus Hall

This gives a fairly good idea of the richness of this basal fauna in northern Ohio. As at the neighboring quarries, the lithological change from the Silurian to the Devonian is not great, but the faunal break is very marked and the contact certain.

The Canadian islands lying to the north of Kelley's Island have sections very similar to those just discussed. The greater portion of the

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east shore of Point Pelee Island is a Devonian rock identical with the Columbus limestone and the same rock has been quarried to a depth of thirty feet near the club house at the northwest point of the island. The common fossils of the Columbus limestone are also the conspicuous ones here.

THICKNESS OF THE MIDDLE DEVONIAN AT SANDUSKY.

In linking together the sections at Sandusky, Marblehead and Kelley's Island in order to determine the thickness of the Columbus limestone, rather startling results are obtained. The equivalence of bed No. 3 in the Wagner quarry No. 2, Sandusky, and bed No. 8 in the Olemacher quarry, Marblehead, was established on its lithological appearance and upon the character, both lithological and faunal, of the beds lying immediately above and below it. The lithology of the layer at the two places is striking enough in itself to make one suspect the equivalence, and the identity of the faunas above and below it makes the case reasonably sure. The identity of "bottom rock" at the Marblehead and Kelley's Island quarries is too evident to need discussion. Using then the South Side quarry, Kelley's Island, the Olemacher quarry, Marblehead, and the Wagner quarry No. 2, Sandusky, the total thickness of the Columbus limestone may be obtained as follows:

Columbus limestone.

	Ft.	In.
c. "Bone-bed" to the base of bed No. 3 of the Wagner quarry No. 2, Sandusky.....	17	0
b. Base of bed No. 8 (the equivalent of bed No. 3 in Wagner No. 2) to the top of "bottom rock" in the Olemacher quarry, Marblehead	13	6
a. Top of "bottom rock" to the Silurian-Devonian contact in the South Side quarry, Kelley's Island	30	6
Total	61	0

This is a decrease of forty-four feet from the total thickness at Columbus. The basal portion of the formation in the Sandusky region carries an abundance of specimens of *Spirifer gregarius*, and perhaps, as Swartz suggests in his diagrams,[1] this is the *Spirifer gregarius* zone of central Ohio and that the diminution in thickness has taken place entirely below that horizon. In support of this view is the absence at Marblehead and Kelley's Island, of the *Spirifer macrothyris* zone, the Gastropod fauna of the chert zone, the Corals of the Coral zone, etc., all of which fall below the *Spirifer gregarius* zone in central Ohio. On

[1] *Op. cit.*, p. 63.

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the other hand none of these horizons have been located north of Marion: in the quarry of the Bellevue Stone Company at Bellevue, where the lower portion of the Columbus limestone and the upper part of the Monroe limestone are well exposed, a true *Spirifer gregarius* zone does not occur, nor has it been located in any other quarry between the Sandusky region and Marion; the rather sparingly fossiliferous lower portion of the Columbus limestone, other than the lowest zone, in the Sandusky region bears a striking structural and lithological similarity to the lower almost barren part of the same formation in central Ohio; and finally the interval between the *Spirifer gregarius* beds and the top of the formation at Marblehead and Kelley's Island is double that of the interval in question at Columbus. This leads to the alternative view that perhaps there has been a diminution in the thickness of the formation as a whole and that the fauna occurring in the base of the formation of the Sandusky region reappears later in the vicinity of Columbus. A probable real loss of the lower massive portion of the formation takes place between the Columbus and Bellefontaine regions.

The Norwalk well gave one hundred thirty feet as the thickness of the Devonian limestones. Substracting the sixty-one feet of Columbus limestone obtained as above, there are sixty-nine feet left as the thickness of the Delaware limestone. The diamond drill core, reported by Mr. Barnes of Sand Hill, showed ninety feet of blue limestone. The Wagner quarry No. 2 gives seventeen feet as the thickness of the blue portion of the Columbus limestone. Substracting this from the ninety feet of the diamond drill core at Sand Hill, it gives seventy-three feet as the thickness of the Delaware limestone. This seems an incredible thickness for that formation, but indications have been that a rapid thickening of the Hamilton formations takes place in northern Ohio, and, since the two methods tally within four feet, perhaps seventy feet may not be too much to assign to this formation. The use of the Sand Hill well section can be valuable only in case the entire formation is still intact, and this is essentially the case.

There are no outcrops, north of those in Franklin and Delaware counties, which give the entire thickness of the Delaware limestone. It seems more than probable, however, that the Barnes quarry represents the upper part of the formation, the Hendrickson quarry the middle and above, while the lowermost layers are known to occur in the Hancock street and Sycamore line quarries at Sandusky, as also in the Lake Shore Railroad quarry south of Venice. There is thus the possibility of a considerable amount of Delaware limestone occurring in the intervals between the sections mentioned.

The thickness of the Olentangy formation in northern Ohio is not definitely known. The Norwalk well gave about eighty feet of marly shales and limestones assigned to this formation, and that is probably

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near the truth. It is certain at least that there has been a very material thickening of this deposit in northern Ohio.

SECTIONS AND FAUNAS OF THE NORTHWESTERN DISTRICT

In the crescent shaped area of Devonian in the northwestern part of the state, the relief of the land is low and drainage seldom cuts through the drift covering to bed rock. The geological structure of this corner is therefore but imperfectly known. However, some good sections of Devonian have been uncovered by artificial means during the past few years, and thus an opportunity to add a little to the knowledge of these important formations has been afforded.

As already pointed out, there are but two Middle Devonian formations represented in this part of the State, the Columbus limestone and the Traverse formation. The Michigan term, Traverse, is introduced here because the rocks referred to it are but the southward extension of the same formation that occurs in that state, and because the rocks carrying a Hamilton fauna in northwestern Ohio cannot well be referred to either of the central and northern Ohio formations which carry a fauna of that age. The Traverse formation is the approximate equivalent of the Delaware limestone and Olentangy shale of the Columbus and Sandusky regions.

The Columbus limestone consists of the usual fossiliferous gray limestone, which passes downward into a sparingly fossiliferous brown limestone resembling the lower part of the same formation in central Ohio. The total thickness of this formation probably does not exceed sixty feet. The Traverse formation consists mainly of limestone, but it also includes some beds of shale and shaly limestone. The limestone of the basal portion of the Traverse is lithologically identical with that of the upper part of the Columbus limestone, the transition being marked only by the introduction of vast numbers of Hamilton species. At the top, however, the Ohio shale rests directly upon a limestone as at Sandusky and hence a decided break occurs.

Silica.[1]—Eight miles west of Toledo and two and a quarter miles southwest of Sylvania is the small quarrying village known as Silica. At this place, which is only a few miles south of the Michigan-Ohio line, the quarries at present being worked are in the Sylvania sandstone and Lucas limestone. Several old quarries in the Devonian, however, are located across the road to the north and west of those of the Toledo Stone and Glass Sand Company, and among these is the old abandoned Lee quarry which furnishes the following section:

[1]Gilbert, G. K., *Geol. Surv., Ohio*, Vol. I, 1873, pp. 575-577.
Also Prosser, C. S., *Jour. Geol.*, Vol. XI, 1903, pp. 540, 541.

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Columbus limestone.

		Ft.	In.
3.	Thin bedded Crinoidal gray limestone containing many Corals	2	0
2.	Massive porous brown limestone with few fossils	9	0
1.	Massive brown limestone containing some poorly preserved fossils and some fossiliferous white chert	2	6

The following species were collected here:

Favosites hemisphericus (Troost)
Stromatopora ponderosa Nicholson
Cystodictya gilberti (Meek)
Atrypa reticularis (Linnæus)
Cyrtina hamiltonensis Hall
Nucleospira concinna Hall
Pholidostrophia iowaensis (Owen)
Productella spinulicosta Hall
Rhipidomella vanuxemi Hall
Spirifer acuminatus (Conrad)
Spirifer gregarius Clapp
Spirifer segmentum Hall
Stropheodonta demissa (Conrad)
Stropheodonta hemispherica Hall
Strophonella ampla Hall
Aviculopecten sp.
Conocardium cuneus (Conrad)
Paracyclas elliptica Hall
Pterinea flabellum (Conrad)
Callonema lichas (?) Hall
Pleurotomaria lucina Hall
Trochonema meekanum Miller
Orthoceras sp.
Phacops cristata Hall

The most interesting section of this locality, however, is that along Ten Mile Creek,[1] just south of the quarries, where the following section may be found.

Traverse formation.

		Ft.	In.
14.	Massive bluish drab limestone containing iron pyrites, traces of petroleum and a few fossils	10	0
13.	Thin unevenly bedded blue limestone with several layers of white chert, both fossiliferous	3	0

[1] *Ohio Nat.*, Vol. VIII, 1908, pp. 271-276.

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		Ft.	In.
12.	Blue shale and soft shaly blue limestone containing much iron pyrites and quite fossiliferous	2	6
11.	Bluish gray limestone alternating with layers of fossiliferous white chert	3	6
10.	A rather compact drab limestone with many fossils, occurring as casts, and much fossiliferous white chert	2	0
9.	Bluish gray shaly limestone with irregular layers of fossiliferous white chert. At places much of this zone becomes a mass of Corals	2	0
8.	Blue limestones interbedded with soft blue shaly layers	4	0
7.	Covered interval, at least in part consisting of blue shale as shown by material dredged from the bottom of the creek. It includes the contact of the Columbus and Traverse formations	20	0

Columbus limestone.

6.	Very fossiliferous crystalline gray limestone	13	0
5.	Compact brown limestone in massive beds and containing a few fossils in the upper part	42	0

Lucas limestone.

4.	Compact drab limestone showing a banded structure. These layers are quite massive but weather into much thinner layers. Several fossiliferous horizons occur near the middle of the zone	63	0
3.	Compact drab limestone with some dark gray to brown sandy layers. This zone is probably the basal portion of the Lucas limestone rather than a part of the underlying formation	36	0

Sylvania sandstone.

2.	A fine grained friable white sand becoming coarser and of a conglomeratic nature in the lower part. The extreme base is made up of limestone pebbles imbedded in the sandstone	43	0

Tymochtee formation.

1.	Thin bedded compact drab limestone exposed at the bottom of the sandstone quarry at Silica, but better along the creek to the east and south	20	0

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The following fauna occurs in the rocks along this creek:

	Horizon.[1]
Cladopora canadensis Rominger	8, 9
Cladopora sp.	8, 9
Cyathophyllum rugosum Hall	6
Cystiphyllum vesiculosum Goldfuss	9
Diphyphyllum panicum (Winchell)	9
Favosites arbusculus Hall	9
Favosites hamiltoniæ Hall	9
Favosites hemisphericus (Troost)	6, 9
Favosites nitellus Winchell	8, 9
Favosites placentus Rominger	9
Favosites radiciformis Rominger	9
Favosites sp.	14
Heliophyllum halli Edwards and Haime	9
Streptelasma ungula Hall	8, 9
Strombodes alpinensis Rominger	9
Syringopora sp.	8, 9
Zaphrentis cornicula Edwards and Haime	6
Zaphrentis simplex Hall	8, 9
Stromatopora granulata Nicholson	9
Stromatopora ponderosa Nicholson	6
Dolatocrinus canadensis (?) Whiteaves	14
Dolatocrinus sp.	14
Gennæocrinus (?) sp.	14
Hexacrinus leai (?) (Lyon)	8, 9
Megistocrinus spinulosus Lyon	6, 14
Cystodictya gilberti (Meek)	6
Dendropora elegantula Billings	8, 9
Fenestella arkonensis Whiteaves	8, 9
Fenestella emaciata (?) Hall	8, 9
Fenestella sp.	9, 10, 11
Fenestrapora biperforata (?) Hall	8, 9
Fistulipora sp	8
Lichenalia sp.	8
Orthopora bipinulata (?) (Hall)	8, 9
Reteporina rombifera (Hall)	8, 9
Reteporina striata (?) (Hall)	8, 9
Stictoporina plumea (Hall and Schuchert)	8, 9
Streblotrypa hamiltonensis Nicholson	8, 9
Ambocœlia umbonata (Conrad)	7, 8, 9
Atrypa reticularis (Linnæus)	6, 8, 14
Atrypa spinosa Hall	6, 14
Camarotœchia horsfordi Hall	14
Centronella ovata Hall	9, 10, 11
Chonetes arcuatus (?) Hall	6
Chonetes coronatus (Conrad)	8, 9
Chonetes deflectus Hall	8, 9

[1]NOTE—The species assigned to horizons 7, 8, 9, 10 and 11 were collected, for the most part, on the banks of the creek among the loose material thrown out in deepening the channel. As many as a half dozen trips have been made to this section, and it is believed that the assignment is fairly correct.

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	Horizon.
Chonetes hemisphericus Hall	5
Chonetes lepidus Hall	8, 9
Chonetes mucronatus (?) Hall	8, 9
Chonetus scitulus Hall	8, 9
Chonetes vicinus (Castelnau)	8, 9
Crania crenistriata Hall	8, 9
Cryptonella planirostris Hall	10
Cyrtina hamiltonensis Hall	6, 8, 9
Dalmanella lepida (?) Hall	8, 9
Eunella lincklæni Hall	8, 9
Gypidula sp.	9, 10, 11
Leiorhynchus kelloggi Hall	8, 9
Leiorhynchus laura (Billings)	8, 9
Lingula ligea Hall	14
Nucleospira concinna Hall	6, 8, 9
Orthothetes sp.	8, 9
Pholidostrophia iowaensis (Owen)	6, 8, 9
Productella spinulicosta Hall	6
Rhipidomella penelope (?) Hall	8, 9
Rhipidomella vanuxemi Hall	6, 8, 9
Schizophoria striatula (Schlotheim)	8, 9
Spirifer acuminatus (Conrad)	6
Spirifer audaculus (Conrad)	8, 9, 10, 11
Spirifer gregarius Clapp	6
Spirifer macrus Hall	8, 9, 11
Spirifer manni Hall	6
Spirifer pennatus (Atwater)	8, 9
Spirifer varicosus Hall	6
Spirifer venustus Hall	8
Spirifer sp.	14
Stropheodonta concava Hall	9, 14
Stropheodonta demissa (Conrad)	6, 8, 9, 14
Stropheodonta hemispherica Hall	6, 8, 9
Stropheodonta perplana (Conrad)	6, 9, 10, 11, 14
Strophonella ampla Hall	6
Tropidoleptus carinatus (?) Conrad	8, 9
Actinopteria boydi Hall	9, 10, 11
Actinopteria decussata Hall	8, 9
Aviculopecten sp.	6, 8
Conocardium cuneus (Conrad)	6
Leiopteria dekayi (?) Hall	8, 9
Limopteria macroptera (Conrad)	8, 9
Limopteria pauperata Hall	6
Paracyclas elliptica Hall	6
Pterinea flabellum (Conrad)	6, 8
Bellerophon cf. pelops Hall	14
Callonema cf. bellatulum (Hall)	11
Callonema lichas (?) (Hall)	6
Loxonema hamiltoniæ Hall	11
Loxonema sp.	14
Pleurotomaria lucina Hall	6
Pleurotomaria sulcomarginata (Conrad)	11

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	Horizon.
Pleurotomaria sp.	9, 10, 11, 14
Trochonema meekanum Miller	6
Coleolus tenuicinctus (?) Hall	8, 9
Tentaculites bellulus Hall	8, 9
Tentaculites scalariformis Hall	6
Gomphoceras pingue (?) Hall	14
Goniatites (?) sp.	14
Orthoceras arkonense Whiteaves	14
Orthoceras cf. eriense Hall	14
Orthoceras sp.	6
Phacops cristata Hall	6
Phacops rana (Green)	8, 9
Proetus macrocephalus Hall	8, 9

This Traverse fauna differs markedly from that of the Hamilton formations east of the anticlinal axis. Even the fossiliferous upper layers near Sandusky carry but a small per cent. of the species found in the Hamilton of this section.

Whitehouse.—About twelve miles south of Silica and sixteen miles southwest of Toledo on the Wabash Railroad, the Columbus limestone is being quarried at the village of Whitehouse. The two quarries in the southeastern edge of the village, formerly the Ryan and Pray, are now operated by the Whitehouse Stone Company, and the following section is uncovered. (See Plate XIII.)

		Ft.	In.
11.	Soil and drift	2	0
	Traverse formation.		
10.	Rather compact crystalline gray limestone containing a great many Corals, especially *Acervularia davidsoni* and *Favosites hemisphericus*	0	6
9.	Compact finely crystalline gray limestone very full of *Chonetes coronatus* associated with *Tropidolpetus carinatus*	0	10
8.	Gray to bluish gray limestone, compact and crystalline. It contains an occasional specimen of *Chonetes coronatus* and *Cyrtina umbonata alpinensis*	2	0
7.	Compact blue to brown limestone markedly less fossiliferous than the other layers	1	6
6.	Very fossiliferous blue to gray limestone containing a great abundance of specimens of *Cyrtina umbonata alpinensis*	1	0
	Columbus limestone.		
5.	Thin uneven bedded bluish gray limestone containing an abundant fauna	9	3

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	Ft.	In.
4. Bluish gray limestone, in three to six-inch layers, containing a variety of fossils, but especially full of *Tentaculites scalariformis*	1	10
3. Light bluish gray limestone in six to fourteen-inch layers. Fossils comparatively few	3	8
2. Massive bluish gray limestone containing pockets of fossiliferous white chert	3	0
1 Massive bluish brown crystalline limestone weathering blue. It contains a good many fossils, but they are generally not well preserved	2	0

There is no distinct line separating the Columbus from the Traverse here. Lithologically and physically the section is continuous, but the introduction of a great abundance of the Hamilton species, *Cyrtina umbonata alpinensis*, is taken as an indication of the certainly changed fauna which is exhibited in the layers a few feet higher in the section.

The following fauna was collected in this quarry:

	Horizon.
Calcisphæra robusta Williamson	5, 6
Acervularia davinsoni Edwards and Haime	9, 10
Cladopora tela Davis	5
Cladopora sp.	10
Cyathophyllum sp.	10
Cystiphyllum vesiculosum Goldfuss	9
Favosites emmonsi Rominger	5
Favosites hemisphericus (Troost)	10
Favosites nitellus Winchell	10
Favosites sp.	5, 10
Syringopora sp.	10
Zaphrentis cornicula Edwards and Haime	5
Zaphrentis gigantea (?) Rafinesque	5
Stromatopora nodulata Nicholson	9, 10
Stromatopora ponderosa Nicholson	5, 10
Syringostroma densa Nicholson	5
Cystodictya gilberti (Meek)	5
Fenestella sp.	5, 6
Monotrypa tenuis (Hall)	10
Amphigenia elongata (Vanuxem)	5
Athyris vittata (?) Hall	8
Atrypa reticularis (Linnæus)	4, 5, 6, 7, 8, 10
Atrypa spinosa Hall	5
Camarotœchia billingsi Hall	5
Chonetes coronatus Conrad	8, 9
Chonetes mucronatus Hall	5, 8
Chonetes sp.	7
Cryptonella lens Hall	5
Cyrtina hamiltonensis Hall	2
Cyrtina umbonata alpinensis Hall	6, 8, 9

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The west wall of the East quarry at Whitehouse. The greater part of this section is Columbus limestone, but a few feet at the top belong to the Traverse.

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	Horizon.
Eunella lincklæni Hall	5
Orthothetes pandora (Billings)	5
Pentamerella arata (Conrad)	5
Pentamerella sp	8
Pholidops patina Hall and Clarke	5
Pholidostrophia iowaensis (Owen)	3, 4, 5
Productella spinulicosta Hall	5, 6
Rhipidomella vanuxemi Hall	5
Schizophoria propinque Hall	5
Spirifer acuminatus (Conrad)	4, 5
Spirifer audaculus (Conrad)	6, 8, 9, 10
Spirifer gregarius Clapp	5
Spirifer grieri (?) (Hall)	5
Spirifer lucasensis n. sp	7, 8
Spirifer manni Hall	5
Spirifer sp.	5, 6
Stropheodonta demissa (Conrad)	5, 6
Stropheodonta hemispherica Hall	4, 5, 6, 8, 9
Stropheodonta inæquiradiata Hall	3, 4, 5
Stropheodonta perplana (Conrad)	9
Tropidoleptus carinatus (Conrad)	9
Aviculopecten sp.	5, 10
Conocardium cuneus (Conrad)	4, 5, 6, 9
Glyptodesma erectum (Conrad)	9, 10
Glyptodesma occidentale Hall	5
Paracyclas elliptica Hall	5, 7, 8
Pterinea flabellum (Conrad)	5, 9
Callonema lichas Hall	5
Loxonema robustum (?) Hall	5
Murchisonia desiderata Hall	5
Murchisonia cf. maia Hall	6
Platyceras carinatum Hall	8
Platyceras dumosum Conrad	5
Platyceras sp.	9
Pleurotomaria arata Hall	5
Pleurotomaria lucina Hall	5
Pleurotomaria sp.	5
Coleolus crenatocinctus Hall	5
Tentaculites scalariformis Hall	2, 3, 4, 5, 6, 7
Gyroceras sp.	5
Orthoceras sp.	5
Dalmanities sp.	8
Phacops cristata Hall	5
Proetus crassimarginatus Hall	5
Proetus planimarginatus Meek	5
Proetus sp	5
Dipterus eastmani n. sp	5

Grand Rapids.[1]—This town is on the south bank of the Maumee River at the point where it is crossed by the Toledo, St. Louis and West-

[1]Winchell, N. H., *Geol. Surv. Ohio*, Vol. II, 1874, p. 379. His "Oriskany sandstone" at Otsego Ford (*ibid*, pp. 380, 381), is the Sylvania sandstone.

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ern Railroad, ten miles south-southwest of Whitehouse and about twenty-five miles southwest of Toledo. At the west end of Main street there is a small quarry exposing six and one-half feet of massive fine grained brown limestone with few fossils. The bottom of the quarry was filled with water, but at the railroad bridge north of town the base of the Columbus limestone is shown resting with a conspicuous uneven bituminous contact upon the Lucas limestone. The lower part of the Devonian appears to be slightly arenaceous here.

Among the abundance of fragmentary fossils, the following were well enough preserved to be identified; Crinoid fragments, *Pholidostrophia iowaensis*, *Spirifer* sp., *Stropheodonta hemispherica*, *Loxonema* sp. *Coleolus crenatocinctus*, *Phacops cristata*, etc.

Junction.—This is a small inland village located in Paulding county at the junction of the East-west and North-south canals, about nine miles southwest of Defiance. The point of interest lies along the Auglaize River, which flows a half mile east of the canal. The last of the Ohio shale may be seen in the bed of this river, about three miles above Defiance. From this point to Charloe, a distance of nearly twelve miles, the river flows on limestone the greater part of the way. The quarries mentioned in the earlier reports[1] are mostly in the bed of Auglaize River, and have never been worked to any considerable depth because of the difficulty in draining them. Just south of the last outcrop of Ohio shale is the Town Newton property, where some rock was taken out and a crusher installed a few years ago. The foot or so of rock shown above the river level here is a rather massive hard fossiliferous bluish gray limestone. A quantity of bluish white chert and cherty limestone, which has been taken from the bottom of this pit and now lies around the old crusher, adds to the similarity of this rock to the upper part of the section along Ten Mile Creek, to which horizon it probably belongs.

The most important section in this region is that of the A. V. Hager quarry, just below the bridge over the Auglaize River, one-half mile east of Junction, where the following measurements were made.

	Ft.	In.
6. Till and boulder clay.....	20	0
Traverse formation.		
5. Fossiliferous blue limestone with much white chert	1	4
4. Rather pure blue limestone. This is the portion that was formerly burned for lime	2	8

[1]Winchell, N. H., *Op. cit.*, pp. 339-341, 427.

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	Ft.	In.
3. Massive layers of compact bluish limestone. There is a thin but conspicuous layer of iron pyrites at the top	7	0
2. Massive layers of impure blue limestone with shaly partings	5	0
1. Very fossiliferous soft blue shale or shaly limestone extending to the bottom of the lowest portion of the quarry	2	0

The following fauna was collected from this section.

	Horizon.
Aulopora serpens Goldfuss	1
Cyathophyllum sp.	3
Heliophyllum halli Edwards and Haime	4, 5
Cystodictya gilberti (Meek)	1, 4
Cystodictya incisurata (Hall)	1
Fenestella sp.	4
Monotrypa sp.	1
Trematoporella sp.	1, 4
Athyris spiriferoides (Eaton)	2
Atrypa reticularis (Linnæus)	2, 3
Chonetes coronatus Conrad	1
Chonetes deflectus Hall	1
Chonetes lepidus Hall	1
Chonetes scitulus Hall	1. 4
Chonetes sp.	2
Crania crenistriata Hall	4
Cyrtina hamiltonensis Hall	1, 2, 4
Rhipidomella cyclas Hall	4
Rhipidomella vanuxemi Hall	1, 2, 4
Schizophoria striatula (Schlotheim)	1, 4
Spirifer pennatus (Atwater)	1
Spirifer sp.	2, 4
Stropheodonta demissa (Conrad)	2, 4
Stropheodonta hemispherica Hall	2, 4
Stropheodonta perplana (Conrad)	1, 4
Glyptodesma erectum (Conrad)	1
Pterinea flabellum (Conrad)	1, 2, 4
Platyceras erectum (Hall)	4
Platyceras sp.	1, 5
Tentaculites scalariformis Hall	1, 4
Orthoceras nuntium Hall	5
Bythocypris indianensis (?) Ulrich	1
Bythocypris cf. punctatus Ulrich	1
Phacops rana (Green)	1, 4
Phacops sp.	2

In the shale at the bottom of the section there are concretionary masses of limestone which are filled with Bryozoans and other fossils. In general the shales and shaly partings of the section are much more fossiliferous than the limestones.

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From a half to three-quarters of a mile up stream from the bridge at Hager's quarry, a considerable amount of limestone was formerly taken from the bed of a small run entering the Auglaize River from the west. The rock at this locality is doubtless lower stratigraphically than that of the Hager quarry, and is a massive blue limestone with shale partings of the same color. The following fauna was collected here:

Aulopora serpens Goldfuss
Cladopora frondosa Nicholson
Heliophyllum halli Edwards and Haime
Romingera unbellifera (Billings)
Trachypora elegantula Billings
Zaphrentis sp.
Fenestella arkonensis Whiteaves
Athyris vittata Hall
Atrypa reticularis (Linnæus)
Cyrtina umbonata alpinensis Hall
Cyrtina sp.
Rhipidomella vanuxemi Hall
Schizophoria striatula (Schlotheim)
Spirifer audaculus (Conrad)
Spirifer pennatus (Atwater)
Stropheodonta concava Hall
Stropheodonta demissa (Conrad)
Pterinea flabellum (Conrad)
Tentaculites bellulus Hall

Scott's Ford.—About two miles up stream from the Hager quarry and just above the mouth of Flat Rock Creek the road crosses the river without a bridge at a place known as Scott's Ford. The stream is here flowing on limestone which, like that further north, dips to the northwest. The section at this place is as follows:

Traverse formation.

		Ft.	In.
5.	Blue limestone with some shaly partings...	3	0
4.	Bluish gray limestone with numerous specimens of *Acervularia davidsoni* and *Favosites hemisphericus*. This is the equivalent of the top layer (No. 10 of section) in the Whitehouse quarry.....	0	6
3.	Bluish gray limestone containing *Chonetes coronatus*	1	0
2.	Bluish gray limestone with an abundant fauna	4	0

Columbus limestone.

1.	Very fossiliferous bluish gray limestone....	1	0

The following is only a small portion of the rich fauna that may be found here:

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	Horizon.
Acervularia davidsoni Edwards and Haime	4
Aulopora serpens Goldfuss	2
Cyathophyllum sp.	2, 4
Favosites hemisphericus (Troost)	3, 4
Zaphrentis sp.	1, 3, 4
Cystodictya gilberti (Meek)	1
Athyris vittata Hall	2
Atrypa reticularis (Linnæus)	1, 2, 3, 4, 5
Camarotœchia sp.	2
Chonetes coronatus Conrad	3
Chonetes sp.	1
Cyrtina hamiltonensis Hall	1, 2
Cyrtina umbonata, alpinensis (?) Hall	4, 5
Delthyris consobrina (d'Orbigny)	4, 5
Nucleospira concinna Hall	1
Pholidops patina Hall and Clarke	1
Pholidostrophia iowaensis (Owen)	1
Productella spinulicosta Hall	1, 2
Spirifer audaculus (Conrad)	3, 4
Spirifer gregarius (?) Clapp	1
Spirifer pennatus (Atwater)	5
Spirifer sp.	1
Stropheodonta concava Hall	5
Stropheodonta demissa (Conrad)	1, 2, 3, 5
Stropheodonta hemispherica Hall	1, 2
Actinopteria boydi (Conrad)	1
Modiomorpha concentrica (Conrad)	1
Schizodus sp.	1
Platyceras sp.	1
Orthoceras constrictum (?) (Vanuxem)	5
Phacops rana (Green)	5

There can be no doubt but Nos. 3 and 4 of this section are the equivalents of Nos. 9 and 10 of the Whitehouse section. The latter section, therefore, lies mostly below, while the Hager quarry lies entirely above the Scott's Ford section.

Antwerp.—Since the abandonment of the old iron furnace at Antwerp, Paulding county, there has been no limestone taken from the bed of the Maumee River and there is little to be seen at the old quarry, as it is below water level much of the time. The few blocks now available carry a Columbus fauna, and it is more than probable that the entire mass of rock belongs to that formation.

THE THICKNESS AND COMPOSITION OF THE MIDDLE DEVONIAN IN NORTHWESTERN OHIO.

It is impossible to determine the exact thickness of the Middle Devonian formations in the northwestern part of the state, since no

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single outcrop gives the entire section and the well records are unsatisfactory.[1] The Ten Mile Creek section, however, is thought to be essentially complete; it certainly gives at least a close approximation to the whole. This makes the total thickness about one hundred twelve feet, of which a little more than half is probably Traverse.

The Columbus limestone, although much reduced in thickness as compared with the central Ohio section, duplicates the formation as it appears east of the anticline. The Traverse formation, or the time equivalent of the Delaware limestone and the Olentangy shale, has changed materially. Faunally it is more decidedly Hamilton than either of the latter, except possibly the Olentangy formation just below the Prout limestone member at Sandusky. While lithologically the resemblance is perhaps more remote, there is still some similarity here. In northwestern Ohio, where the thickness of the Hamilton has greatly diminished and the amount of shale in comparison to the limestone has become insignificant, and at Sandusky, where the reverse is true, the Hamilton consists of limestone at top and bottom with a shale between. This same arrangement holds for Ontario, where the Hamilton has a thickness of more than two hundred feet,[2] but here with limestones intercalated in the shaly middle portion. An interesting, and perhaps significant, feature of this Ontario Hamilton is that it also "passes into the Corniferous limestone" as the Traverse does at Whitehouse and Scott's Ford.

CONCLUSION.

From the foregoing record of sections and faunas, it seems to be a safe deduction that the Middle Devonian in Ohio is confined to the Onondaga and Hamilton phases; that these two divisions are as distinct as those of the same age in any other region; and that the history of these formations in this state has been an integral part of that of the adjacent territory. Hence the following correlation of these formations[3] with New York divisions has been assumed:

	Ohio		New York
Middle Devonian	Traverse	Olentangy formation	Hamilton Beds
		Delaware limestone	Marcellus shale
	Columbus limestone		Onondaga limestone

[1] *Geol. Surv. Ohio*, Vol. VI, 1888, pp. 243-254.
[2] Gibson, Thomas W., 12th Rept. *Ont. Bur. Mines*, 1903, p. 42.
[3] See *Jour. Geol.*, Vol. XV 1907, p. 596.

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CHAPTER III.

THE RELATIONSHIPS OF THE MIDDLE DEVONIAN FAUNAS OF OHIO.

INTRODUCTION.

The animal life of any geological period may be separated into a number of more or less distinct faunas which are intimately related to the conditions under which they existed. Among marine faunas, such as those under consideration, the more important factors influencing life are: the temperature of the sea, its salinity and depth; the presence of land barriers between portions of the same or different basins; the existence of favorable or unfavorable currents; the amount and kind of detritus which is being brought down by running water; the kind and abundance of food to be obtained; the presence or absence of hostile or rival faunas, etc.

Perhaps no other single condition, which has influenced the distribution of fossil faunas, has received so much consideration as has that of the ancient land barriers and continents—the paleogeography of the earth. The former existence of land connections between continents now separated is accepted by all geologists, and to the vertebrate paleontologist a demonstrated fact, since it is an obvious impossibility for land animals, which must have arisen from the same ancestors, to spread over widely separated land areas unless there existed some means of easy communication between them. The effect of such a barrier on marine faunas is of course absolutely prohibitive to migration in that direction. Other conditions, however, must at times be equally unfavorable to migration. Thus a fossiliferous bed of limited extent may be found within a formation of almost barren strata. This is well illustrated by the colony of Crinoids in the Olentangy shale at Delaware, Ohio. Here within the barren shales is a lens of limestone, 5 inches thick and traceable along the cliff for a distance of 13½ feet, which is made up almost entirely of the fragments of Crinoids. No other such bed is known anywhere within the formation.

But the matter of the distribution of life is still more complicated by the fact that a barrier for one species may not check another at all, or, if so, only temporarily. Thus a fauna is often found to change gradually by the elimination of those species unsuitable to the new con-

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ditions and the addition of others better adapted to the changed conditions, until finally the association of species is so different that it is indeed a different fauna.

GENERAL DISTRIBUTION.

The difficulty of properly delimiting ancient faunal provinces lies chiefly in the inability to obtain a full collection of species from some of the most critical localities and, as yet, insufficient knowledge of other localities where such collections might be obtained. However, certain more or less well defined areas in various parts of the earth are known to have formed portions of the Devonian epicontinental seas. Among these may be mentioned: southern Australia and a portion of New Zealand, South Africa, the region north of Lake Tchad in the Sahara, a portion of Asia Minor and Persia, north central Siberia, central and southern China, portions of Japan, the northern and southern provinces of Europe, a considerable portion of South America, and the various provinces of North America. These districts all bear certain broad faunal relations to one another, as might be expected in distant portions of the sea of any period. Thus certain species of Corals and Brachiopods are found in Europe, Asia, Australia and South America which are considered identical with the North American species. So close is the relation between the Devonian faunas of Europe and certain faunal provinces of North America, and again between North and South America, that there can be no doubt but that conditions developed which favored migration between these portions of the ancient Devonian sea.

DISTRIBUTION IN NORTH AMERICA.

In North America the Devonian outcrops are usually grouped together in four general areas.[1] These are:

The Eastern Border Area, including Gaspé, New Brunswick, and northern New England.

The Eastern Continental Area, best known in New York, Ontario, Michigan, Ohio, Indiana, southern Illinois, Kentucky and less perfectly southward to the Gulf states.

The Interior Continental Area developed in west central Illinois, Missouri, Iowa and thence northwestward through Manitoba and along the valley of the Mackenzie River.

The Western Continental Area in the Great Basin region, including portions of Nevada, California and adjacent territory.

In addition to these a fifth, the Western Border Area, might be made to include the Devonian rocks of the islands off the southeastern coast of Alaska.[2]

[1]Williams. H. S., *Am. Jour. Sci.*, 3rd Ser., Vol. XXXV, 1888, pp. 51-59.
[2]Kindle, E. M., *Jour. Geol.*, Vol. XV, 1907, pp. 314-337.

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These provinces have had more or less of an independent history, but at times there must have been an intimate connection between certain of them, since a fauna which normally occurs in one is found lapping over into another basin and there mingled with the species indigenous to that territory in strata above those containing the usual fauna of that province. The history of the incursions of these provincial faunas[1] into the interior basin of the Eastern Continental Area comprises one of the most interesting events in the development of North American faunas.

THE EASTERN CONTINENTAL SEA.

By the close of the Silurian, the ancient epicontinental sea which covered the greater part of the present Mississippi basin, had withdrawn from a large part of the interior, and the territory now occupied by Ohio and adjoining states to the west and north, together with a large tract beyond, was dry land. This withdrawal probably took place to the north, to the south, and to a less extent to the east, with the Cincinnati arch bowing up into a complete barrier between these various portions of the sea. With the beginning of the Devonian a readvance of the sea set in, but Ohio was not affected until the Middle Devonian when a considerable portion of its territory was again invaded. The pebbles of this old shore line are still to be found in the basal conglomerate of the Columbus region. Thus the Devonian begins in Ohio with a marked unconformity, below which the rocks vary in age from Niagaran to Cayugan, and above it from Onondaga to Hamilton.

OUTCROPS IN OHIO.

On account of its peculiar outline, the Eastern Interior sea was naturally divided into several basins, of which those bordering the Cincinnati land mass may be referred to as, the Ohio basin to the east, the Michigan basin to the north, and the Indiana basin to the west. (See Plates XV and XVI.) The outcrops of Middle Devonian within the state follow the borders of the Michigan and Ohio basins, so that there is a crescent shaped area in the northwest and to the east a strip crossing the central part of the state from north to south, with an outlier at Bellefontaine. The history of these two areas, separated by a ridge of Silurian limestones, has been somewhat different both in sedimentation and in life development.

THE CENTRAL DISTRICT.

The central strip is made up of three formations of this age, the Columbus limestone, the Delaware limestone, and the Olentangy shale,

[1]Weller, Stuart, *Jour. Geol.*, Vol. X, 1902, pp. 423-432; Schuchert, Charles, *Am. Geol.*, Vol. XXXII, 1903, pp. 137-162.

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all of which are very distinct divisions in the vicinity of Columbus. Within each of these three formations there are several zones containing faunal associations quite distinct in themselves. Among these latter may be mentioned the Coral zone, the Eversole chert or Gastropod zone, the *Spirifer gregarius* zone of the Columbus limestone, and the "Marcellus" zone of the Delaware limestone. These are all of much interest and have received their proportional consideration. It is with the broader general relations, however, that the present discussion is concerned and only incidentally with these zones as they may throw some light on the migratory movements of the whole fauna.

The following table gives the fauna obtained from the formations of this area of outcrops:

FAUNA OF THE MIDDLE DEVONIAN OF THE CENTRAL DISTRICT.

INVERTEBRATA.

	Columbus.	Delaware.	Olentangy.
RHIZOPODA			
Calcisphæra robusta Williamson	x	..	..
SPONGIAE			
*Receptaculites devonicus Whitfield	x	..	..
ANTHOZOA			
Aulacophyllum convergens Hall	x	..	..
Aulacophyllum sulcatum (d'Orbigny)	x	..	..
Aulopora serpens Goldfuss	..	x	..
Bothrophyllum cinctutum Davis	x	..	..
Chonophyllum magnificum (?) Billings	x	..	..
Cladopora frondosa Nicholson	x	..	..
Cladopora pulchra Rominger	x	..	..
Cladopora robusta Rominger	x	..	..
Cladopora tela (?) Davis	x	..	..
Cyathophyllum multigematum (?) Davis	x	..	..
Cyathophyllum rugosum Edwards and Haime	x	..	..
Cyathophyllum validum Hall	x	..	..
Cystiphyllum ohioense Nicholson	x	..	..
Cystiphyllum sulcatum (?) Billings	x	..	..
Cystiphyllum vesiculosum Goldfuss	x	x	..
Cystiphyllum sp.	x	..	..
Diphyphyllum archiaci Billings	x	x	..
Diphyphyllum bellis (?) Davis	x	..	..

*Not collected by the writer.

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	Columbus.	Delaware.	Olentangy.
Diphyphyllum simcoense (Billings)	x	..	..
Diphyphyllum stramineum Billings	x	..	..
Diphyphyllum strictum (Edwards and Haime)	x	..	..
Diphyphyllum verneuilanum (Edwards and Haime	x	..	..
Diphyphyllum sp.	x	x	..
*Favosites basalticus Goldfuss	x	..	..
Favosites emmonsi Rominger	x	?	..
Favosites goldfussi d'Orbigny	x	..	..
Favosites hemisphericus (Troost)	x	x	..
Favosites limitaris (?) Rominger	x	..	..
Favosites maximus (Troost)	x	..	..
Favosites pleurodictyoides Nicholson	x	..	..
Favosites radiciformis Rominger	x	..	..
Favosites sp.	x	x	..
Hadrophyllum d'orbignyi Edwards and Haime	x	x	..
Heliophyllum halli Edwards and Haime	x	x	..
Heliophyllum porcilatum Hall	x	..	..
Heliophyllum sp.	..	x	..
*Michelinia convexa d'Orbigny	x	..	..
Pleurodictyum problematicum Goldfuss	x	..	..
Stylastrea anna Whitfield	x	..	..
Syringopora perelegans Billings	..	..	x
Syringopora tabulata Edwards and Haime	x	..	..
Syringopora sp.	x	..	..
Zaphrentis cornicula Edwards and Haime	x	..	..
*Zaphrentis edwardsi Nicholson	x	..	..
Zaphrentis gigantea Rafinesque	x	..	..
Zaphrentis prolifica Billings	x	..	..
Zaphrentis spissa (?) Hall	x	..	..
Zaphrentis ungula (?) Rominger	x	..	..
Zaphrentis wortheni Nicholson	x	..	..
Zaphrentis sp.	x	x	..
HYDROZOA.			
Dictyonema leroyensis Gurley	x	..	..
Stromatopora nodulata Nicholson	x	..	..
Stromatopora ponderosa Nicholson	x	x	..
Stromatopora sub-striatella Nicholson	x	..	..
Stromatopora sp.	x	x	..
Syringostroma columnaris Nicholson	x	..	..
*Syringostroma densa Nicholson	x	..	..
CRINOIDEA			
*Dolatocrinus cælatus (?) Miller and Gurley	x	..	..
*Dolatocrinus glyptus (Hall)	x	x	..
*Dolatocrinus greenei (?) Miller and Gurley	x	..	..

*Not collected by the writer.

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	Columbus.	Delaware.	Olentangy.
*Dolatocrinus lacus Lyon	x	..	..
*Dolatocrinus liratus (Hall)	x	x	..
*Dolatocrinus major Wachsmuth and Springer	x	..	..
*Dolatocrinus ornatus Meek	x	..	..
Dolatocrinus sp.	x	..	..
*Megistocrinus depressus (Hall)	x	..	..
*Megistocrinus rugosus Lyon and Casseday	x	..	..
Megistocrinus spinulosus Lyon	x	..	..
Melocrinus sp.	..	..	x
BLASTOIDEA			
Codaster pyramidatus Shumard	x	..	..
Nucleocrinus venustus (?) Miller and Gurley	..	x	..
Nucleocrinus verneuili (Troost)	x	..	..
BRYOZOA			
Coscinium striatum Hall and Simpson	x	..	..
Cystodictya gilberti (Meek)	x	x	..
Cystodictya ovatipora (Hall)	..	x	..
Cystodictya sp.	x	..	x
Fenestella biseriata (?) Hall	..	x	..
Fenestella erectipora (?) Hall	x	..	..
Fenestella parallela (?) Hall	x	..	..
Fenestella sp.	x	x	x
Fistulipora substellata (?) Hall	x	..	..
Fistulipora vesiculata (Hall and Simpson)	..	x	..
Fistulipora sp.	x	x	..
Hederella canadensis Nicholson	..	..	x
Lichenalia sp.	x	..	..
Lioclema multiculeatum (Hall)	..	..	x
Monotrypa tenuis (Hall)	x	..	..
Monotrypa sp.	x	x	..
Nemataxis fibrosus Hall	x	..	..
Orthopora regularis Hall	..	x	..
Orthopora sp.	..	x	..
Polypora celsipora (Hall)	x	..	..
Polypora celsipora minima (?) (Hall)	x	..	..
Polypora flabelliformis (?) (Hall)	x	..	..
Polypora robusta (Hall)	x	..	..
Polypora sp.	x	..	..
Prismopora triquetra Hall	x	..	..
Semicoscinium bi-imbricatum (Hall)	x	..	..
Semicoscinium semi-rotundum (?) (Hall)	x	..	..
Stictopora sp.	x	..	..
Trematella arborea (?) (Hall)	..	x	..
Trematella sp.	..	x	x

*Not collected by the writer.

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	Columbus.	Delaware.	Olentangy.
Unitrypa lata (Hall)	x	x	..
Unitrypa tegulata (Hall)	x	..	..
BRACHIOPODA			
Ambocœlia umbonata (Conrad)	..	x	x
Amphigenia elongata (Vanuxem)	x	..	..
Athyris spiriferoides (Eaton)	..	..	x
Athyris vittata indianaensis n. var	x	x	..
Atrypa reticularis (Linnæus)	x	x	x
Atrypa spinosa Hall	x	x	..
Camarospira eucharis Hall	x	x	..
Camarotœchia billingsi Hall	x	x	..
Camarotœchia carolina Hall	x	..	..
*Camarotœchia dotis Hall	..	x	..
Camarotœchia prolifica Hall	..	x	..
Camarotœchia sappho Hall	..	x	..
Camarotœchia tethys (Billings)	x	x	..
Camarotœchia sp.	x	x	..
Centronella glansfagea Hall	x	..	..
*Charionella scitula Hall	x	..	..
*Chonetes acutiradiatus Hall	x	..	..
Chonetes arcuatus Hall	x	..	..
Chonetes coronatus Conrad	..	x	x
Chonetes deflectus Hall	..	x	x
Chonetes hemisphericus Hall	x	..	..
Chonetes mucronatus Hall	x	x	..
Chonetes scitulus Hall	..	x	..
Chonetes setigerus (?) (Hall)	..	x	x
Chonetes yandellanus (?) Hall	x	..	..
Chonetes sp.	x	..	..
Chonostrophia reversa (Whitfield)	?	x	..
Crania crenistriata Hall	x	?	?
Crania sp.	x	..	..
Cryptonella lens Hall	x	..	..
Cyrtina crassa Hall	x	..	..
Cyrtina hamiltonensis Hall	x	x	..
Delthyris consobrina (d'Orbigny)	..	x	..
Delthyris raricosta Conrad	x	..	..
Eunella lincklæni Hall	x	x	..
Eunella sullivanti Hall	x	x	..
Eunella sp.	x	x	..
Leiorhynchus kelloggi Hall	..	x	x
Leiorhynchus laura (Billings)	..	x	x
Leiorhynchus limitare (Vanuxem)	..	x	..
Leiorhynchus sp.	..	..	x
Leptæna rhomboidalis (Wilckens)	x	x	..
Lingula ligea Hall	..	x	..
Lingula manni Hall	..	x	..

*Not collected by the writer.

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	Columbus.	Delaware.	Olentangy.
Martinia maia (Billings)	..	x	..
Meristella nasuta (Conrad)	x	..	..
Meristella rostrata (?) Hall	x	..	..
Meristella sp.	x	..	..
Metaplasia disparalis (Hall)	x	..	..
Nucleospira concinna Hall	x	..	..
Orbiculoidea doria (Hall)	..	x	..
Orbiculoidea lodiensis (Vanuxem)	..	x	..
Orbiculoidea minuta (Hall)	..	x	..
Orbiculoidea sp.	..	..	x
Orthothetes chemungensis perversus (Hall)	..	x	..
*Orthothetes flabellum (Whitfield)	x	..	..
Orthothetes pandora (Billings)	x	x	..
Pentamerella arata (Conrad)	x	..	..
Pentamerella pavilionensis Hall	..	x	..
Pholidops patina Hall and Clarke	x	..	..
Pholidostrophia iowaensis (Owen)	x	x	..
Productella spinulicosta Hall	x	x	..
Reticularia fimbriata (Conrad)	x	..	..
Rhipidomella cleobis Hall	x	..	..
Rhipidomella livia (Billings)	x	?	..
Rhipidomella vanuexmi Hall	x	x	..
Rhipidomella sp.	x	x	..
*Rhynchonella (?) raricosta Whitfield	x	..	..
*Roemerela grandis (Vanuxem)	..	x	..
Schizophoria propinque Hall	x	..	..
Schizophoria striatula (Schlotheim)	..	..	x
Spirifer acuminatus (Conrad)	x	..	..
Spirifer audaculus (Conrad)	..	x	..
Spirifer audaculus macronatus Hall	..	x	..
Spirifer divaricatus Hall	x	..	..
Spirifer duodenarius (Hall)	x	..	..
Spirifer fornacula Hall	x	..	..
Spirifer gregarius Clapp	x	..	..
Spirifer grieri Hall	x	..	..
Spirifer lucasensis n. sp	..	x	..
Spirifer macrus Hall	x	x	..
Spirifer macrothyris Hall	x	..	..
Spirifer manni Hall	x	..	..
*Spirifer marcyi Hall	..	x	..
Spirifer pennatus (Atwater)	..	..	x
*Spirifer segmentum Hall	x	..	..
Spirifer varicosus Hall	x	..	..
Spirifer sp.	x	x	x
Strophalosia cf. truncata (Hall)	x	..	..
Stropheodonta concava Hall	x	x	x
Stropheodonta demissa (Conrad)	x	x	x

*Not collected by the writer.

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	Columbus.	Delaware.	Olentangy.
Stropheodonta hemispherica Hall	x	x	..
Stropheodonta inæquiradiata Hall	x	..	..
Stropheodonta inæquistriata (Conrad)	x	x	..
Stropheodonta parva (?) Hall	x	x	..
Stropheodonta patersoni Hall	x	..	..
Stropheodonta perplana (Conrad)	x	x	x
Stropheodonta sp.	..	x	..
Strophonella ampla Hall	x	..	..
PELECYPODA			
Actinopteria boydi (Conrad)	x	..	x
Actinopteria sp.	x	..	?
Aviculopecten cleon Hall	x	?	?
*Aviculopecten æquilateris Hall	..	x	..
Aviculopecten exactus (?) Hall	..	x	..
Aviculopecten fasciculatus Hall	..	..	x
*Aviculopecten parilis (Conrad)	x	x	..
Aviculopecten cf. pecteniformis (Conrad)	x	..	..
Aviculopecten princeps (Conrad)	x	x	..
Aviculopecten sp.	x	x	x
*Clinopistha antiqua Meek	x	..	..
Conocardium cuneus (Conrad)	x	x	..
Conocardium cuneus attenuatum (Conrad)	x	..	..
Conocardium cuneus subtrigonale d'Orbigny	x	..	..
Conocardium ohioense Meek	x	..	..
Conocardium sp.	x	x	..
*Cypricardella major (Hall)	..	x	..
Cypricardella tenuistriata (Hall)	..	x	..
Cypricardinia indenta (?) Conrad	..	..	x
Glossites teretis (?) Hall	x	..	..
Glyptocardia speciosa Hall	..	..	x
Glyptodesma erectum (Conrad)	..	x	..
Glyptodesma occidentale Hall	x	..	..
Goniphora cf. hamiltonensis Hall	x	..	..
Grammysia arcuata (Conrad)	x	..	..
Grammysia bellatula Hall	..	..	x
Grammysia bisulcata (Conrad)	..	x	x
Grammysia ovata Hall	..	x	..
Grammysia secunda (?) Hall	x	..	..
Grammysia subarcuata (?) Hall	x	..	..
Leiopteria rafinesquii Hall	..	x	x
Limopteria pauperata Hall	x	..	..
Macrodon sp.	..	x	..
*Modiomorpha complanata Hall	..	x	..
Modiomorpha concentrica (Conrad)	x	..	..
Modiomorpha subalata (Conrad)	..	..	x
Modiomorpha sp.	x	..	x
Mytilarca cf. carinata Hall	..	..	x

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	Columbus.	Delaware.	Olentangy.
Mytilarca percarinata Whitfield	x	..	..
Mytilarca sp.	..	x	..
Nucula niotica Hall and Whitfield	x	..	..
Nucula sp.	x	..	..
Nuculites triqueter Conrad	..	..	x
Nyassa arguta Hall	..	x	..
*Panenka alternata Hall	x	..	..
Palaeoneilo (?) sanduskiensis n. sp	..	x	..
Paracyclas elliptica Hall	x	x	..
Paracyclas lirata (Conrad)	..	x	..
Paracyclas ohioensis Meek	x	..	..
Paracyclas sp.	x	..	..
Pholidella sp.	..	..	x
Plethomytilus ponderosa Hall	x	..	..
Pterinea flabellum (Conrad)	x	..	x
*Pterinea similis Whitfield	x	..	..
Ptychopteria (?) sp.	x	..	..
Sanguinolites (?) sanduskiensis Meek	x	..	..
Schizodus appressus (Conrad)	x	..	x
Schizodus contractus Hall	x	..	..
Schizodus tumidus Hall	x	..	..
Schizodus sp.	..	x	..
Solemya vestuta Meek	x	..	..
Sphenotus cuneatus (Conrad)	..	x	x
GASTROPODA			
Bellerophon acutilira (?) Hall	x	..	..
Bellerophon hyalina Hall	x	..	..
Bellerophon lyra Hall	..	..	x
Bellerophon newberryi Meek	x	..	..
Bellerophon pelops Hall	x	?	..
Bellerophon rotalinea (?) Hall	x	..	..
Bellerophon sp.	x	x	x
Callonema bellatulum (Hall)	x	..	..
Callonema clarki Nettelroth	x	..	..
Callonema initator Hall and Whitfield	x	..	..
Callonema lichas (Hall)	x	..	..
Callonema sp.	x	..	..
Cœlidium strebloceras (?) Clarke	x	..	..
Cyclonema crenulatum Meek	x	..	..
Cyclonema sp.	x	..	..
Cyrtonella mitella Hall	..	..	x
Dentalium martini Whitfield	x	..	..
Euomphalus decewi Billings	x	x	..
Isonema depressum Meek and Worthen	x	..	..
Isonema humile Meek	x	..	..
Loxonema gracillium Whiteaves	x	..	..
Loxonema læviusculum Hall	x	..	..

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	Columbus.	Delaware.	Olentangy.
Loxonema parvulum Whitfield	x	..	..
Loxonema pexatum Hall	x	..	..
Loxonema pexatum obsoletum Hall	x	..	..
Loxonema robustum Hall	x	..	..
Loxonema sicula (?) Hall	x	..	..
Loxonema sp.	x	..	..
Macrocheilus hebe (?) (Hall)	x	..	..
Macrocheilus macrostoma (Hall)	x	..	..
Macrocheilus prisca (Whitfield)	x	..	..
Macrocheilus sp	x	..	..
Murchisonia desiderata Hall	x	..	..
Murchisonia desiderata var. Hall	x	..	..
Murchisonia eversolensis n. sp	x	..	..
Murchisonia intermedia n sp	x	..	..
Murchisonia leda Hall	x	..	..
Murchisonia maia Hall	x	..	..
Murchisonia quadricarinata n. sp	x	..	..
Murchisonia sp.	x	..	..
Naticopsis æquistriata Meek	x	..	..
Naticopsis comperta Hall	x	..	..
Naticopsis lævis Meek	x	..	..
Naticopsis sp.	x	..	..
Orthonema newberryi Meek	x	..	..
Palæotrochus kearneyi (Hall)	x	..	..
Platyceras attenuatum Hall	x	..	..
Platyceras blatchleyi Kindle	x	..	..
Platyceras bucculentum Hall	x	x	..
Platyceras carinatum Hall	x	x	..
Platyceras cymbium Hall	x	..	..
Platyceras dumosum Conrad	x	x	..
Platyceras erectum (Hall)	x	x	x
Platyceras multispinosum Meek	x	..	..
Platyceras nodosum Conrad	..	x	..
*Platyceras rarispinosum Hall	x	..	..
Platyceras rictum Hall	x	..	..
*Platyceras squalodens Whitfield	x	..	..
Platyceras thetis Hall	x	..	..
Platyceras sp.	x	x	..
Platystoma lineatum Conrad	x	..	..
Platystoma subglobosa n. sp	x	..	..
Pleurotomaria adjutor Hall	x	..	..
Pleurotomaria cancellata n. sp	x	..	..
Pleurotomaria capillaria (?) Conrad	..	..	x
Pleurotomaria dublinensis n. sp	x	..	..
Pleurotomaria hyphantes Meek	x	..	..
Pleurotomaria insolita Hall	x	..	..
Pleurotomaria lucina Hall	x	..	..

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	Columbus.	Delaware.	Olentangy.
Pleurotomaria plena Hall	x	..	..
Pleurotomaria procteri Nettelroth	x	..	..
Pleurotomaria regulata (?) Hall	x	x	..
Pleurotomaria rotalia Hall	..	..	x
Pleurotomaria sciotoensis n. sp	x	..	..
Pleurotomaria sp.	x	x	x
*Porcillia scioto Hall and Whitfield	x	..	..
Porcillia hertzeri Hall	..	x	..
Pseudophorus antiquus Meek	x	..	..
Strapharollus corrugatus n. sp	x	..	..
Strophostylas varians Hall	x	..	..
Trochonema meekanum Miller	x	..	..
Turbo shumardi Verneuil	x	..	..
PTEROPODA			
Coleolus crenatocinctus Hall	x	..	..
Coleolus sp.	x	..	..
*Conularia elegantula Meek	..	x	..
Styliola fissurella Hall	..	..	x
Tentaculites scalariformis Hall	x	x	..
CEPHALOPODA			
Agoniatites discoideus (Hall)	x	..	..
*Anarcestes cf. lateceptatus Beyrich	x	..	..
Cyrtoceras cretaceum Whitfield	x	..	..
Cyrtoceras metula (?) Hall	x	..	..
Cyrtoceratites ohioensis Meek	x	..	..
Discites ammonis (?) Hall	..	x	..
*Discites inopinatus Hall	x	..	..
*Gomphoceras amphora Whitfield	x	..	..
*Gomphoceras crenatum Hall	x	..	..
Gomphoceras eximium Hall	x	..	..
*Gomphoceras gomphus Hall	x	..	..
*Gomphoceras hyatti Whitfield	x	..	..
*Gomphoceras impar Hall	x	..	..
*Gomphoceras mitra Hall	x	..	..
Gomphoceras plenum Beecher	x	..	..
*Gomphoceras sciotense Whitfield	x	..	..
Gomphoceras sp.	x	x	..
Gyroceras columbiense Whitfield	x	..	..
Gyroceras cyclops Hall	x	..	..
*Gyroceras seminodosum Whitfield	x	..	..
Gyroceras sp.	x	x	..
*Gyroceratites inelegans Meek	x	x	..
Gyroceratites ohioensis Meek	x	x	..
*Orthoceras dagon Hall	x	..	..
Orthoceras eriensis (?) Hall	..	x	..
*Orthoceras molestum Hall	x	..	..

*Not collected by the writer.

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	Columbus.	Delaware.	Olentangy.
Orthoceras nuntium Hall	x	..	..
Orthoceras ohioensis Hall	x	x	..
Orthoceras sirpus Hall	x	..	..
Orthoceras thoas Hall	x	..	..
*Orthoceras winchelli Meek and Worthen	x	..	..
Orthoceras sp.	..	x	x
*Tornoceras mithrax (Hall)	x	..	..
*Trematoceras ohioense Whitfield	x	..	..
CRUSTACEÆ			
Barychilina sp.	..	..	x
Bollia sp.	..	..	x
Bythocypris indianensis (?) Ulrich	..	..	x
Bythocypris cf. punctatus Ulrich	..	..	x
Chasmops anchiops Green	x	..	..
Chasmops calypso Hall	x	..	..
Coronura diurus (Green)	x	..	..
*Coronura ohioensis Meek	x	..	..
Dalmanites sp.	x	..	..
Odontocephalus ægeria Hall	x	..	..
Odontocephalus bifidus Hall	x	..	..
Phacops cristata Hall	x	..	..
Phacops rana (Green)	..	x	x
Phacops sp.	x	x	..
Proetus crassimarginatus Hall	x	..	..
Proetus planimarginatus Meek	x	..	..
Proetus rowii (Green)	x	x	..
Proetus welleri n. sp	x	..	..
Proetus sp.	x	x	..
VERTEBRATA			
PISCES			
*Acanthaspis armata Newberry	x	x	..
*Acantholepis fragilis Newberry	x	x	..
*Asterosteus stenocephalus Newberry	..	x	..
*Cladodus prototypus Eastman	x	..	..
*Coccosteus occidentalis Newberry	..	x	..
*Coccosteus spatulatus Newberry	..	x	..
*Coelolepis sp.	x	..	..
*Cyrtacanthus dentatus Newberry	x	..	..
*Dinichthys precursor Newberry	x	..	..
*Machæracanthus major Newberry	x	x	..
*Machæracanthus peracutus Newberry	x	x	..
*Machæracanthus sulcatus Newberry	x	x	..
Macropetalichthys rapheidolabis Norwood and Owen	x	x	..
Onychodus sigmoides Newberry	x	x	..

*Not collected by the writer.

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	Columbus.	Delaware.	Olentangy.
*Palæomylus crassus (Newberry).....	x	x	..
*Palæomylus frangens (Newberry).....	x	x	..
*Protitanichthys fossatus Eastman.....	..	x	..
*Psammodus antiquus Newberry.....	x	..	..
*Rhynchodus secans Newberry.....	x	x	..
*Thelodus sp.	x	..	..

DISCUSSION OF THE COLUMBUS FAUNA.

An inspection of this table shows at a glance the extraordinary importance of the Coral element in the Columbus limestone, and yet many of the specimens collected were so indefinite that no attempt was made to identify them.

Attention has so frequently been called to the fossil Coral reef at the Falls of the Ohio that it has become a classic locality in geology. A similar reef extends along the Scioto River for a distance of nearly twenty miles, although unfortunately it is not so strikingly exposed as the one beyond the Cincinnati anticline. In this bed the Corals occur in the utmost profusion, often imbedded in a matrix composed of fragments resulting from their own destruction, some still maintaining their original position and remaining in an excellent state of preservation. Coral reefs also occur in the Onondaga limestone of New York,[1] in the Devonian of Belgium, and some of the same reef building species are identified even in Australia,[2] but nowhere are they known to be better developed than on the east and west sides of the Cincinnati arch. In Ontario the best development of the Devonian Corals is perhaps in the vicinity of Villa Nova,[3] where extensive deposits occur made up largely of the skeletons of these animals. Along the Kwataboahegan River, southwest of James Bay, great numbers of Corals occur[4] and here again the same species are found as in the central Ohio region. In southern Illinois, however, where the Onondaga phase is so well developed,[5] the Coral element is reduced to a few species of rather rare occurrence, in a fauna rich in species[6] of this age. The Devonian of South America is almost destitute of Corals,[7] while the middle Devonian of western Europe and

*Not collected by the writer.

[1]For a discussion of Paleozoic Coral Reefs, see Grabau, A. W., *Bull. Geol. Soc. Am.*, Vol. XIV, 1903, pp. 337-352.

[2]Jack, Robert L. and Robert Etheridge, Jr., *Geol. and Pal. of Queensland and New Guinea*, 1892, p. 48.

[3]Parks, W. A., 12th Rept. *Ont. Bur. of Mines*, 1903, pp. 142, 143.

[4]Parks, W. A., 13th Rept. *Ont. Bur. of Mines*, 1904, p. 181.

[5]Savage, T. E., *Ill. State Geol. Surv.*, Bull. No. 8, 1907, pp. 106, 113, 114.

[6]Weller, Stuart, *Jour. Geol.*, Vol. V, 1897, pp. 626-632.

[7]Katzer, Friedrich, *Grundzüge der unteren Amazonasgebietes*, 1903, p. 192, pl. 9, (Leipzig).

Also Knod, Reinhold, *Neues Jahrbuch*, Vol. XXV, (Beilage Band), 1908, p. 574.

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of Siberia has a rich Coral fauna[1]. This certainly has a significant bearing on the direction of migration of this element of the fauna, and especially since the lower Devonian faunas of Gaspé are also poor in its possible forebearers[2].

Extensive Coral reefs occur in the Silurian rocks of Wisconsin[3] and Iowa[4], and it is a fact worthy of note that among the 16 genera listed in the above tabulation, 11 genera were also represented in the Silurian, while even the Stromatoporoids which are so abundant in the Devonian Coral beds near Columbus, are represented in these older deposits. If the Silurian Corals retreated northward upon the withdrawal of the sea, and there continued to thrive in some as yet unknown province,[5] just such a relationship would be expected between the old fauna and the new which would return with a readvance of the sea. This northern origin of the Corals is still further supported by the fact that at Cayuga, Ontario, 52 species occurring in the Oriskany sandstone are common to the Onondaga limestone, while in New York state and Maryland only 7 bear this relation.[6] Of this number of common species 19 are Corals. Weller has suggested that the commingling of Onondaga and Oriskany forms at this most northern point of the Eastern Continental area, where the latter fauna is known, may indicate the locality where "the Corniferous (Onondaga) fauna first came in contact with the Oriskany."[7]

The vicinity of Columbus has long been known as a representative region for the Onondaga fauna, and in no other phase is this so well illustrated as among the species of Brachiopods which may be found here; in fact almost any species which occurs in any other part of the Eastern Continental area, together with some forms at one time thought to be exclusively Hamilton, may be expected in the Columbus limestone. The great majority of the species indicate the close relationship to the Ontario and New York expressions of the fauna that their direct communication leads one to expect. Certain species, however, such as *Cyrtina hamiltonensis*, *Stropheodonta perplana*, *Spirifer duodenarius*, *Spirifer macrothyris*, etc., together with other forms closely allied to Columbus species, occur in the Upper Oriskany of southern Illinois,[8] while *Stropheodonta perplana*, *Chonetes mucronatus*, *Chonostrophia reversa*, etc., are found also in the Oriskany of Tennessee,[9] and in South America a kindred fauna, with some of these very species, lived in the lowest Devonian (Oriskany?).[10]

[1]Lebedew, N., *Mem. du Comité Géologique*, Vol. XVII, No. 2, 1902, pp. 1-130, 137-180.
[2]Clarke, J. M., *N. Y. State Mus. Mem.* 9, 1908, pp. 243-252.
[3]Chamberlin, T. C., *Geol. Surv. Wis.*, Vol. II, 1877, pp. 349-371.
[4]Calvin, Samuel, *Geol. Surv. Ia.*, Vol. V, 1896, pp. 79-81.
[5]Weller, Stuart, *Jour. Geol.*, Vol. X, 1902, p. 429.
[6]Hall, James, 8th Ann. Rept. *N. Y. State Geol.*, 1888 (1889), pp. 51-54.
[7]*Op. cit.*, p. 430.
[8]Savage, T. E., *Op. cit.*, p. 113.
[9]Schuchert, Charles, *Am. Jour. Sci.*, 4th Ser., Vol. VII, 1899, pp. 430-432.
[10]Katzer, Friedrich, *Op. cit.*, pp. 192-196, 202, 210, 211, pls. 10, 11. Also Knod, Reinhold, *Op. cit.*, pp. 573-574.

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Among the species above referred to it is worthy of note that *Spirifer duodenarius* has been found only in the upper ten feet of the Columbus limestone. *Spirifer macrothyris* is found in the middle and lower parts of the formation, and at Harrisburg, south of Columbus, it is one of the most plentiful fossils in a rock that is nothing but a mass of Brachiopod remains. At Sandusky the species was not found at all nor is it reported from the James Bay region, although it occurs at Cayuga, Ontario. *Chonostrophia reversa* has been questionably identified in the very top layers of the Columbus, although it is a common fossil in the overlying Delaware limestone. On the other hand, *Spirifer gregarius*, which is such an abundant fossil in the Columbus limestone, has not been identified in the middle Devonian fauna of southern Illinois. The species occurs in Ontario, and on the islands of Lake Erie and at Marblehead it is the dominant form in the very base of the formation, while in the central part of the state it does not become abundant until a little above the middle of the formation. *Meristella nasuta* is another species which occurs in Ontario, even in the James Bay region, and in central Ohio is the most important fossil of a distinct zone just below the middle of the formation. This fossil, like *Spirifer gregarius*, is found as far south as the Falls of the Ohio but is not known in southern Illinois. Other species, such as *Camarospira eucharis*, *Cyrtina crassa*, *Metaplasia disparalis*, etc., show the same relation, but they are among the rare species of the Columbus fauna.

It seems rather doubtful whether the Eastern Border area had a direct connection with the Eastern Continental area during Onondaga time. At least there is no indication of migration in that direction, since the fauna of this age is not represented as such in the Gaspé region.[1] There is, however, an association of Brachiopods in the Grande Grève limestone (Oriskany) which is also a part of the Columbus fauna. These are *Centronella glansfagea*, *Reticularia fimbriata*, *Delthyris raricosta*, *Stropheodonta parva*, *Stropheodonta patersoni*, and *Strophonella ampla*. The occurrence of most of these species in the Upper Oriskany of southern Illinois is certainly suggestive of the route which they followed in reaching the Ohio region, although some of them are among those which pass from the Oriskany (transition beds) to the Onondaga at Cayuga, Ontario. The few Onondaga Corals collected at Lake Memphremagog[2] and near the city of Quebec seem to suggest that these patches of Middle Devonian are outliers from the great deposits to the southwest and not indicators of a former connection between this area and the Eastern Border area.

Most of the Brachiopods of the Columbus limestone have a wide distribution throughout the area of which it forms a part. The new

[1]Clarke, J. M., *Op. cit.*, p. 251.
[2]Ami, Henry M., Ann. Rept. *Geol. Surv. Can.*, Vol. VII, N. S., 1894, p. 157 J.

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conditions developed in an advancing sea are eminently favorable for the rapid evolution of life; hence it is probable that many species have not migrated far from their initial locality, while in other cases the antecedent faunas may be obscured by immigration from other localities. Possibly the great majority of the species of this vigorous fauna, from whatever source, spread over the newly acquired territory contemporaneous with the advance of the sea, and only the few less inclined to migrate remained as a vanguard and thus indicate the direction from which others have come.

The Pelecypod element is hardly so useful a means of comparison. It is well represented, both to the north and to the south, and perhaps better in either direction than in Ohio. Unfortunately, those of the farther north have not been fully determined as yet. A rather close relationship to the Eastern Border area is indicated by the fact that, of the 19 genera definitely identified from the Columbus limestone, about a dozen genera are common to the Grande Grève (Oriskany) limestone, among which *Schizodus appressus* and *Conocardium cuneus* are species represented in both regions. At least 8 of the Ohio genera are represented in the early Devonian of Brazil,[1] and several of the species are closely allied. Essentially the same relation obtains in Bolivia[2].

It is to be regretted that our knowledge of the faunas of the few but important outcrops of Middle Devonian in Mississippi, Alabama, and Georgia is too meager to be of assistance in indicating the direction of migration of these faunas, and the deposits of southern Illinois have not as yet shown a very important Pelecypod element. While there are a number of species represented, Pelecypods are not among the fossils usually abundant in the Columbus limestone. One species, however, may have a definite bearing of a character different from that indicated above; this is *Paracyclas elliptica*, which is one of the more common Columbus Pelecypods. In north central Europe the genus is represented in the upper part of the Lower Devonian.[3] It is to be noted that while this species occurs in southern Illinois, not even the genus is represented in the Gaspé region or in South America. *Plethomytilus ponderosa* and *Mytilarca percarinata* are also probably found to the north, but so far not in Indiana, Illinois or Kentucky, and again not even the genera in South America, although *Mytilarca* is represented in the Gaspé region.

The Gastropod fauna is exceptionally rich and specimens of the larger forms are abundant, especially in the middle and upper part of the formation. A large number of species, however, were found only in the limited cherty layers (the Gastropod zone) below the middle of

[1]Schuchert, Charles, *Jour. Geol.*, Vol. XIV, 1906, pp. 744, 745.
[2]Knod, Reinhold, *Op. cit.*, pp. 572, 573.
[3]Kayser, Emanuel, *Lehrbuch der Geologie*, dritte auflage, teil 2, 1908, p. 184, pl. 14.

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the formation. Of the 20 genera in the above list, four are also known in the Lower Devonian of South America and at least one of these, *Strophostylas varians*, is identical. *Euomphalus decewi*, *Loxonema robusta*, *Murchisonia desiderata*, etc., are common to Ohio and to the James Bay region, but are not known in southern Illinois.

The Cephalopods are an important element in this fauna and are distributed throughout the formation. They are also among the abundant forms of the James Bay region[1], and at least *Orthoceras* is common to this and the Ohio region. The southern Illinois fauna contains but a few genera of Cephalopods, and except *Gomphoceras*, these are all rare. Three genera occur in the Gaspé region, but the Lower Amazon has not yielded a single Cephalopod, and Bolivia only one species of the genus *Orthoceras*.[2]

The occurrence of the first Goniatites known in America is an event of much importance. Three genera—*Tornoceras*, *Agoniatites* and *Anarcestes*—are represented with one species each. The Goniatites have their best early development in central Europe,[3] where they are represented by about a half dozen genera in the Middle and Lower Devonian, with a few even in the Silurian.

The Trilobites are remarkably similar throughout. *Dalmanites* and *Phacops* are among the common genera in the Devonian of the Lower Amazon, of Gaspé, and of Ohio. *Phacops cristata*, a common fossil of the Columbus limestone and the same horizon northward, occurs also in the Oriskany of Tennessee and southern Illinois. *Odontocephalus* is perhaps indigenous to the region and an evolution product of the Oriskany, since its nearest relative seems to be in that fauna. The almost universal distribution of the Trilobites has been observed at other horizons, especially in the Cambrian, and by way of explanation it has been suggested that their larvæ composed a part of the Plankton which ocean currents quickly carried to all parts of the sea.[4] Trilobites are thus well suited to correlation purposes, but give little assistance in an attempt to discover the source of a fauna.

Fish remains have been found in the middle of the formation and continue to be important throughout the remainder of the Ohio Devonian. The same genera and many of the same species occur in the Delaware as in the Columbus limestone. On account of the association of the early fishes with Eurypterids and other evidences of fresh water or littoral conditions, it has been suggested[5] that the Ordovician and Silurian fishes lived in the rivers and fresh water lakes. The first ap-

[1]Parks, W. A., *Op. cit.*, pp. 188-190.
[2]Knod, Reinhold, *Op. cit.*, pp. 502, 503.
[3]Kayser, Emanuel, *Op. cit.*, pp. 187, 189, pls. 17, 19; also Barrande, Joachim, *Système Silurien du centre de la Bohême*, Vol. II, 1865, pp. 28-42, pls. 1-12, etc.
[4]Kayser, Emanuel, *Op. cit.*, p. 78.
[5]Chamberlin, T. C., *Jour. Geol.*, Vol. VIII, 1900, pp. 400-412.

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pearance of marine fishes in North America seems to have been in the Gaspé region during Lower Devonian time.[1] It is to be noted, however, that only one genus, and of that the species also, *Machaeracanthus sulcatus*, is common to the Middle Devonian of the Eastern Continental region. At least one of the common Ohio species, *Macropetalichthys rapheidolabis*, is found in the Devonian southward of James Bay[2] and two genera occur in the Devonian of Spitzbergen.[3]

Eastman's list of the fishes from the Eastern Continental area includes all of the genera known to occur in the Eifel and Bohemia regions of Europe and five in addition, which seems to indicate that this region is nearer to the original source of this important element of the fauna than either of the latter regions. Fish remains are among the rare fossils of southern Illinois. In Bolivia such fossils are said to occur[4] although up to the present none have been specifically identified from the South American region.

FAUNAL ELEMENTS OF THE COLUMBUS.

As a whole, then, this fauna may be considered as composed of two elements—a southern[5] somewhat related to the faunas of the older sediments of the Gaspé region and of the Lower Amazon, Bolivia, and Argentine, which at least in part had reached Tennessee and southern Illinois by the latter part of the Oriskany, together with other species which may have originated in some nearer territory; and a northern[6] much more distinctive element consisting especially of the Corals, the Cephalopods and the fishes, which bear such relations to the faunas of northern and central Europe as to make it seem certain that these found entrance by way of the north, possibly along the present shallows[7] connecting Europe and America through Iceland and Greenland. The Hudson Bay is a shallow epi-continental sea in a region of low relief and great stability—a neutral region. It may therefore have persisted throughout a long period of time and perhaps is even the remnant of the old northern Paleozoic sea through which these faunas found entrance to the Eastern Continental sea. This is suggested not only by the deposit of Devonian in the James Bay region but by the remnants on Southampton Island and others less perfectly known to the north.[8] As Clarke's studies have shown, the Onondaga fauna is undifferentiated

[1]Eastman, C. R., *N. Y. State Mus. Mem.* 10, 1907, p. 13; *Geol. Surv. Ia.*, Vol. XVIII, 1908, pp. 275, 276.
[2]Whiteaves, J. F., *Geol. Surv. Can.*, Rept. of Prog., 1875-76, (1877), pp 319, 320.
[3]Eastman, C. R., *Op. cit.*, p. 193.
[4]Knod, Reinhold, *Op. cit.*, p. 574.
[5]Ulrich, E. O., and Charles Schuchert, *N. Y. State Mus. Bull.* 52, 1902, p. 652.
[6]Weller, Stuart, *Jour. Geol.*, Vol. X, 1902, p. 429.
[7]Chamberlin, T. C., *Jour. Geol.*, Vol. VI., 1898, p. 603.
[8]Schuchert, Charles, *Am. Geol.*, Vol. XXXII, 1903, p. 155.

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in the Eastern Border region. But more than that, it lacks the two most distinctive elements of the fauna, the Corals and Cephalopods, and so many others that if a Connecticut channel[1] was functional during Onondaga time, certainly this portion of the fauna could not have found entrance to the Eastern Continental sea by way of Gaspé. Perhaps rather the species which came from the Eastern Border region migrated south and came in by the same route as did those coming from South America.

The fauna shows pretty clearly that there could have been no immediate connection with the Devonian sea of Iowa and the northwest. In fact it is even probable that no such sea existed while the Onondaga was being deposited in the Eastern Continental region.

The similarity of some species, and the possible identity of others, of the Western Continental area[2] to those occurring in the Eastern Continental area makes it seem that a possibility of migration between the two regions may have existed.[3] Schuchert has suggested a southern connection through Central America,[4] and this would seem to be substantiated by the work of the Mexican Geological Survey[5] as also by the map of North America published by the Geological Congress.[6] But these identifications of Devonian are not beyond question, as the deposits in general are highly metamorphosed; it is reasonably certain, however, that the Mississippian sea crossed at about this point.[7]

DISCUSSION OF THE DELAWARE AND OLENTANGY FAUNA.

The fauna of the Delaware limestone and the Olentangy shale is exceedingly poor as compared with that of the Columbus limestone. This is true not merely of the number of species but of the individual specimens as well. The Delaware limestone begins with a zone, often a true shale, carrying among others the most distinctive fossil, *Leiorhynchus limitare*, of the Marcellus shale of New York. This is more characteristic of the Columbus region, although it has been observed in the northern part of the state as well. Of the Delaware limestone proper the fauna is mostly a remnant of the Columbus limestone species which have withstood the Marcellus conditions. In addition to these species, which are those usually common to the Onondaga and

[1]Schuchert, Charles, *Op. cit.*, pp. 155, 156, pls. 20 and 21.
Also *Geol. Surv. Ia.*, Vol. XVIII, 1908, pl. 14.
[2]Walcott, Charles D,. *Monog. U. S. Geol. Surv.*, Vol. VIII, 1884, pp. 99-211, pls. 13-17.
[3]In this connection see also Kindle, E. M., *U. S. Geol. Surv.* Bull. No. 391, 1909, pp. 1-36, pls. I-X.
[4]*Geol. Surv. Iowa*, Vol. XVIII, 1908, pls. 14-16.
[5]Aguilera, José G., *Boletin del Instute Geológico de Mexico*, Nos. 4, 5 and 6, p. 198, Map opp. p. 270.
[6]Gannett, H. and B. Willis, *Carte Géologique de l'Amérique du Nord. Congrès Géologique International Xe Session*, 1906.
[7]Sapper, K., *Peterman's Geographische Mitteilungen*, Vol. LII, 1906, p. 237.

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Hamilton in the Eastern Continental region, there are also certain other forms, such as *Ambocœlia umbonata, Chonetes coronatus, Chonetes scitulus, Delthyris consobrina, Leiorhynchus laura, Spirifer audaculus, Grammysia bisulcata, Nyassa arguta, Sphenotus cuneatus*, etc., which are rather distinctively Hamilton. The Olentangy shale, which forms the upper member of the Middle Devonian in Ohio, is usually barren of fossils except for the local Crinoidal layer at Delaware. In the Sandusky region, however, these shales, especially the marly limestone near the top and the crystalline limestone at the very top, carry a considerable fauna. The abundant forms of this upper zone are: *Spirifer pennatus, Chonetes deflectus, Leiorhynchus kelloggi, Stropheodonta demissa, Stropheodonta perplana, Schizophoria striatula, Grammysia bisulcata, Modiomorpha subalata, Phacops rana*, etc., decidedly the Hamilton fauna of New York and Ontario.

The Hamilton is in the main a derivative from the Onondaga fauna, but it also possesses certain foreign elements which are equally characteristic. Among these latter forms are *Chonetes coronatus, Tropidoleptus carinatus*, and *Ambocœlia umbonata*, which are known in the early Devonian of Bolivia, Brazil, and Argentine,[1] while a single specimen of *Tropidoleptus carinatus* is known from the Oriskany of Maryland.[2] Other species such as *Schizophoria striatula* and *Athyris spiriferoides* (*concentrica*) are represented in the Middle Devonian of Europe and may have migrated west from that locality. Schuchert has suggestd that the European element may have entered by way of the Connecticut trough,[3] but his more recent paleogeographic map[4] would seem to indicate that he has abandoned the idea of a Connecticut trough for the Hamilton.

Rocks of Hamilton age probably occur in the vicinity of James Bay. A few species, among which is *Spirifer pennatus*, have been collected in a red clay[5] of that region and furnish about the only evidence at present known which seems to indicate the development of these beds in that locality. In southern Illinois the Hamilton beds are well represented and contain a characteristic fauna.[6] The absence of some species, however, especially among the Coelenterata and the Mollusca, is certainly in contrast to the Ohio fauna.

The relationships of the South American Devonian faunas are rather with the Oriskany and as a source of certain of the Onondaga forms, but a decided Hamilton relation is also indicated by the fauna of the

[1]Knod, Reinhold, *Op. cit.*, pp. 545-551. Also Ulrich, Arnold, *Neues Jahrbuch*, Vol. VIII, (Beilage Band), 1893, pp. 73-75, 79, 80, pls. IV, V. Also Bordenberger, W., *Zeit. d. Deut. geol. Ges.*, Vol. XLVII, 1896, pp. 748-754.
[2]Schuchert, Charles, *Jour. Geol.*, Vol. XIV, 1906, p. 733.
[3]*Am. Geol.*, Vol. XXXII, 1903, pp. 156, 162.
[4]*Geol. Surv. Iowa*, Vol. XVIII, 1908, pl. 15.
[5]Whiteaves, J. F., *Am. Geol.*, Vol. XXIV, 1899, p. 231.
[6]Savage, T. E., *Op. cit.*, pp. 105, 114, 115.

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upper beds. This is especially shown by the Brachiopods and the Trilobites,[1] and less clearly in the Pelecypods.

The species common to the Eastern Continental and the Interior Continental areas are such as have a wide range and distribution. The real mingling of these faunas probably did not take place until late Hamilton (Tully) time,[2] and then apparently along the route suggested by Schuchert, that is, past the Milwaukee region[3] and through the Michigan basin.

THE NORTHWESTERN DISTRICT.

In northwestern Ohio a two fold division of the Middle Devonian is observed, the lower consisting of the Columbus limestone and the upper of the Traverse formation, which latter is regarded as the equivalent of the Delaware limestone and the Olentangy shale to the east of the Cincinnati anticline. The Columbus limestone is quite fossiliferous, especially in the upper part; the lower being less fossiliferous, as is also the case in central Ohio. The small number of species listed from this formation in the following table indicates rather the few outcrops than the paucity of its fauna.

FAUNA OF THE MIDDLE DEVONIAN OF THE NORTHWESTERN DISTRICT.

INVERTEBRATA.

RHIZOPODA.

	Columbus.	Traverse.
Calcisphæra robusta Williamson	x	?

ANTHOZOA.

Acervularia davidsoni Edwards and Haime	x	x
Aulopora serpens Goldfuss	..	x
Cladopora canadensis Rominger	..	x
Cladopora frondosa Nicholson	..	x
Cladopora tela Davis	x	..
Cladopora sp.	..	x
Cyathophyllum rugosum Edwards and Haime	x	..
Cyathophyllum sp.	..	x
Cystiphyllum vesiculosum Goldfuss	..	x
Diphyphyllum panicum (Winchell)	..	x
Favosites alpinensis Winchell	..	x
Favosites arbusculus Hall	..	x
Favosites emmonsi Rominger	x	..
Favosites hamiltoniæ Hall	..	x
Favosites hemisphericus (Troost)	x	x

[1] Katzer, F., *Op. cit.*, p. 199, pl. 15.
[2] Weller, Stuart, *Jour. Geol.*, Vol. XVII, 1909, pp. 265, 266, 268.
[3] *Am. Geol.*, Vol. XXXII, 1903, pp. 149, 150, pl. 21.

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	Columbus.	Traverse.
Favosites nitellus Winchell	..	x
Favosites placentus Rominger	..	x
*Favosites polymorphus Goldfuss	x	..
Favosites radiciformis (?) Rominger	..	x
Favosites sp.	..	x
Heliophyllum halli Edwards and Haime	..	x
Romingeria umbellifera Billings	..	x
Streptelasma ungula Hall	..	x
Strombodes alpinensis Rominger	..	x
Syringopora sp.	..	x
Trachypora elegantula Billings	..	x
Zaphrentis cornicula Edwards and Haime	x	..
Zaphrentis gigantea (?) Rafinesque	x	..
Zaphrentis simplex Hall	..	x
Zaphrentis sp.	x	x
HYDROZOA		
Stromatopora granulata Nicholson	..	x
Stromatopora nodulata Nicholson	..	x
Stromatopora ponderosa Nicholson	x	..
Syringostroma densa Nicholson	x	..
CRINOIDEA.		
Dolatocrinus canadensis (?) Whiteaves	..	x
Dolatocrinus sp.	..	x
Genneaocrinus sp.	..	x
Hexacrinus leai (?) (Lyon)	..	x
Megistocrinus spinulosus Lyon	..	x
BLASTOIDEA.		
*Nucleocrinus verneuili (Troost)	x	..
BRYOZOA.		
Cystodictya gilberti (Meek)	x	x
Cystodictya incisurata (Hall)	..	x
Fenestella arkonensis Whiteaves	..	x
Fenestella emaciata (?) Hall	..	x
Fenestella sp.	..	x
Fenestrapora biperforata (?) Hall	..	x
Fistulipora sp.	..	x
Lichenalia sp.	..	x
Monotrypa tenuis (Hall)	x	..
Monotrypa sp.	..	x
Orthopora bipinulata (?) Hall	..	x
Reteporina rhombifera (Hall)	..	x
Reteporina striata (?) (Hall)	..	x
Stictoporina plumea (Hall and Simpson)	..	x
Streblotrypa hamiltonensis Nicholson	..	x
Trematoporella sp.	..	x

*Not collected by writer.

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BRACHIOPODA.

	Columbus.	Traverse.
Ambocœlia umbonata (Conrad)	..	x
Amphigenia elongata (Vanuxem)	x	..
Athyris spiriferoides (Eaton)	..	x
Athyris vittata Hall	..	x
Athyris vittata indianaensis n. var	x	..
Atrypa reticularis (Linnæus)	x	x
Atrypa spinosa Hall	x	x
Camarotœchia billingsi Hall	x	..
Camarotœchia horsfordi Hall	..	x
Camarotœchia sp.	..	x
Centronella ovata Hall	..	x
Chonetes arcuatus Hall	x	..
Chonetes coronatus (Conrad)	..	x
Chonetes deflectus Hall	..	x
Chonetes hemisphericus Hall	x	..
Chonetes lepidus Hall	..	x
Chonetes mucronatus Hall	x	x
Chonetes scitulus Hall	..	x
Chonetes vicinus (Castelnau)	..	x
Chonetes sp.	x	x
Crania crenistriata Hall	..	x
Crania sp.	..	x
Cryptonella lens Hall	x	x
Cryptonella planirostris Hall	..	x
Cyrtina hamiltonensis Hall	x	x
Cyrtina umbonata alpinensis Hall	?	x
Cyrtina sp.	..	x
Dalmanella lepida (?) Hall	..	x
Delthyris consobrina (d'Orbigny)	..	x
Eunella lincklæni Hall	x	x
Gypidula sp.	..	x
Leiorhynchus kelloggi Hall	..	x
Leiorhynchus laura (Billings)	..	x
Lingula ligea Hall	..	x
Nucleospira concinna Hall	x	x
Orthothetes pandora (Billings)	x	..
Orthothetes sp.	..	x
Pentamerella arata (Conrad)	x	..
Pholidops patina Hall and Clarke	x	..
Pholidostrophia iowaensis (Owen)	x	x
Productella spinulicosta Hall	x	x
Rhipidomella cyclas Hall	x	x
Rhipidomella penelope (?) Hall	..	x
Rhipidomella vanuxemi Hall	x	x
Schizophoria propinque Hall	x	..
Schizophoria striatula (Schlotheim)	..	x
Spirifer acuminatus (Conrad)	x	..
Spirifer audaculus (Conrad)	..	x
Spirifer audaculus macronotus Hall	..	x
Spirifer gregarius Clapp	x	..
Spirifer grieri (?) Hall	x	..
Spirifer lucasensis n. sp	..	x

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	Columbus.	Traverse.
Spirifer macrus Hall	?	x
Spirifer manni Hall	x	..
Spirifer pennatus (Atwater)	..	x
Spirifer segmentum Hall	x	..
Spirifer varicosus Hall	x	..
Spirifer venustus Hall	..	x
Spirifer sp.	x	x
Stropheodonta concava Hall	..	x
Stropheodonta demissa (Conrad)	x	x
Stropheodonta hemispherica Hall	x	x
Stropheodonta inæquiradiata Hall	x	..
Stropheodonta perplana (Conrad)	x	x
Strophonella ampla Hall	x	..
Tropidoleptus carinatus (Conrad)	..	x

PELECYPODA.

Actinopteria boydi (Conrad)	x	x
Actinopteria descussata Hall	..	x
Aviculopecten sp.	x	x
Conocardium cuneus (Conrad)	x	x
Glyptodesma erectum (Conrad)	..	x
Glyptodesma occidentale Hall	x	..
Leiopteria dekayi (?) Hall	..	x
Limopteria macroptera (Conrad)	..	x
Limopteria pauperata Hall	x	..
Paracyclas elliptica Hall	x	..
Modimorpha concentrica (Conrad)	x	..
*Panenka alternata Hall	x	..
Pterinea flabellum (Conrad)	x	x
Schizodus sp.	x	..

GASTROPODA.

Bellerophon cf. pelops Hall	..	x
Callonema cf. bellatulum (Hall)	..	x
Callonema lichas (Hall)	x	..
Cyclonema liratum Hall	..	x
*Euomphalus decewi Billings	x	..
*Isonema humile Meek	x	..
Loxonema hamiltoniæ Hall	..	x
Loxonema robustum (?) Hall	x	..
Loxonema sp.	..	x
Murchisonia desiderata Hall	x	..
Murchisonia cf. maia Hall	..	x
Platyceras carinatum Hall	x	..
Platyceras dumosum Conrad	x	..
Platyceras erectum (Hall)	..	x
Platyceras sp.	x	x
Platystoma lineatum Conrad	..	x
Pleurotomaria arata Hall	x	..
Pleurotomaria lucina Hall	x	..

*Not collected by writer.

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	Columbus.	Traverse.
Pleurotomaria sulcomarginata Conrad	..	x
Pleurotomaria sp.	..	x
Trochonema meekanum Miller	x	..
PTEROPODA.		
Coleolus crenatocinctus Hall	x	..
Coleolus tenuicinctus (?) Hall	..	x
Tentaculites bellulus Hall	..	x
Tentaculites scalariformis Hall	x	..
CEPHALOPODA.		
Gomphoceras pingue (?) Hall	..	x
Goniatites sp.	..	x
Gyroceras sp.	x	..
Orthoceras arkonense Whiteaves	..	x
Orthoceras constrictum (?) Vanuxem	..	x
Orthoceras cf. eriense Hall	..	x
Orthoceras nuntium Hall	..	x
*Orthoceras ohioense Hall	x	..
Orthoceras sp.	x	..
CRUSTACEÆ.		
Bythocypris indianensis (?) Ulrich	..	x
Bythocypris cf. punctatus Ulrich	..	x
Phacops cristata Hall	x	..
Phacops rana (Green)	..	x
Phacops sp.	..	x
Proetus crassimarginatus Hall	..	x
Proetus macrocephalus Hall	..	x
Proetus planimarginatus Meek	x	..
*Proetus rowii (Green)	x	..
VERTEBRATA.		
PISCES.		
Dipterus eastmani n. sp	x	..

DISCUSSION OF THE COLUMBUS FAUNA.

The fauna of the Columbus limestone in the above table is essentially the same as in central Ohio. Only one and possibly two species were obtained in this northwestern region which were not found to the east of the anticline. In the Wabash area of Indiana, where the Onondaga phase ranges from zero to about six feet, 42 per cent. of the species of Brachiopoda, Mollusca, and Crustaceæ given above have been identified,[1] while the scarcity of the Corals is a striking feature. In the quar-

*Not collected by writer.

[1]Kindle, E. M., 25th Ann. Rept. of the *Ind. Dept. Geol. and Nat. Res.*, 1900, pp. 565-569.

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ries at Whitehouse, Ohio, and at Scott's Ford on the Auglaize River, the Columbus limestone grades into the overlying Traverse without a break. The sudden appearance of *Chonotes coronatus* associated with *Tropidoleptus carinatus* is the most marked feature of the transition. The dividing line between the two formations has, however, been drawn a little lower to include a zone containing a great abundance of *Cyrtina umbonata alpinensis*. There is thus not the slightest indication of the Marcellus, either faunally or in the character of the sediments, since distinctive Hamilton forms appear in the pure crystalline gray limestone identical with that of the Columbus.

DISCUSSION OF THE TRAVERSE FAUNA.

A study of the Traverse fauna shows a relatively greater importance of the Corals than occurred in the Hamilton of the central strip. At one horizon near the middle of the formation there is a decided Coral bed; and again just above the zone containing *Chonetes coronatus* and *Tropidoleptus carinatus* there is another thin Coral bed in which the abundant species are *Acervularia davidsoni* and *Favosites hemisphericus*. In this it is almost the exact counterpart of the fauna in the Grand Traverse region of Michigan.[1] To make the similarity more striking, there are a few Stromatoporoids occurring in the layers just below the *Tropidoleptus* zone. The central part of Ohio shows no such importance of the Corals in the Hamilton, and the entire absence of some of the more characteristic species, such as *Acervularia davidsoni*, *Zaphrentis simplex*, *Favosites nitellus*, etc. Among the Brachiopods the differences are not so apparent, and yet they are important, especially when considered in connection with the horizons at which certain species occur. In the Hamilton of central Ohio *Chonetes coronatus* is an exceedingly rare fossil, while *Tropidoleptus carinatus* was not collected at all, although it has been reported from the upper part of the Olentangy shale. As mentioned above, these two species are the most conspicuous fossils of an important zone near the base of the formation. Both species have a wide geographical distribution and a considerable vertical range, but neither of them found entrance into the Ohio region until Hamilton time, so they are still diagnostic for this horizon. It should be noted that neither of these species are found in the Interior Continental or in the Western Continental area. *Chonetes coronatus* is rather doubtfully reported from Milwaukee,[2] and both are found in Illinois and Indiana. The *Athyris vittata* is not the variety found at the Falls of the Ohio and in central Ohio, but is identical with the form occurring at Milwaukee. *Cyrtina umbonata alpinensis*, which has not been found in the central part

[1] Winchell, Alexander, Rept. on the Lower Penn. of Mich., 1866, pp. 38-59, and appendix, pp. 83-97.

[2] Whitfield, R. P., *Geol. Wis.*, Vol. IV, 1882, pp. 327, 328.

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of the state, but is typical at Alpena, Michigan, is an abundant species. *Leiorhynchus kelloggi* is a common fossil in the deposits of this region, as also at Sandusky and at Milwaukee, but not even the genus is known in the Interior Continental area. The Mollusca are essentially the same as in the central strip, and are not very different from this portion of the fauna occurring at Milwaukee. The fauna of the Grand Traverse region[1] of Michigan is a similar association of species, while over 40 per cent. of the northwestern Ohio Hamilton fauna occurs at Thedford, Ontario.[2] Nearly 53 per cent. of the Traverse fossils in this table were also identified in the Hamilton of the central Ohio region, but many of them are rare, and others, such as *Spirifer pennatus*, have been found only in the upper part of the Olentangy shale. The Hamilton fauna of Indiana and Illinois is almost the same. It differs from that of northwestern Ohio, principally in the unimportance of its Corals and, among these, in the absence of diagnostic forms; the scarcity of Crinoids; and in the absence of *Cyrtina umbonata alpinensis*, *Leiorhynchus kelloggi*, *Athyris vittata*, etc., which are among the abundant Brachiopods of the Ohio region. In other words, the regions in question contain the essential constituents of the Hamilton fauna, but show a marked tendency to provincialism.

In the Wabash area of Indiana, which lies in the path of the supposed connection between the Michigan and the Indiana basins, the Hamilton is represented by about 14 feet of impure brown limestone, sometimes in part a true sandstone. The entire fauna given[3] for this deposit is nine species, of which only three, *Spirifer pennatus*, *Atrypa reticularis*, and *Cyrtina hamiltonensis*, are common to the northwestern Ohio Hamilton. All of these have a wide geographic distribution, while only the one, *Spirifer pennatus*, is a diagnostic Hamilton form.

LAND BARRIERS.

Exclusive of the local domings of the Niagara in northern Indiana, there is a broad anticline extending from Marion and Peru northward into Illinois near Momence.[4] The Devonian limestones are not known to cross this fold, although the Black shales are supposed to do so at Crown Point.[5] In northwestern Ohio the Devonian formations dip towards the center of the Michigan basin at an angle of 1° to 5°. A similar dip, at least for the Trenton, is indicated by well records in northern Indiana,[6] while to the south of this fold or ridge the Devonian dips into the

[1]Grabau, Amadeus, Ann. Rept. for 1901, *Geol. Surv. Mich.*, 1902, pp. 175-210.

[2]Whiteaves, J. F., Cont. to *Can. Pal.*, Vol. I, pt. 5, 1898, pp. 412-418. Also Grabau, Amadeus, Bull. *Geol. Soc. Am.*, Vol. XIII, 1902, 180-185.

[3]Kindle, E. M., *Op. cit.*, pp. 563, 564.

[4]Gorby, S. S., 15th Ann. Rept. *Geol. Surv. Ind.*, 1886, pp. 228-241. Also Kindle, E. M., *Am. Jour. Sci.*, 4th Ser., Vol. XV., 1903, p. 463.

[5]Leverett, Frank, 17th Ann. Rept., *U. S. Geol. Surv.*, pt. 2, 1896, p. 800.

[6]Phinney, A. J., 11th Ann. Rept. *U. S. Geol. Surv.*, pt. 1, 1891, pp. 648-653, pls. 64-66.

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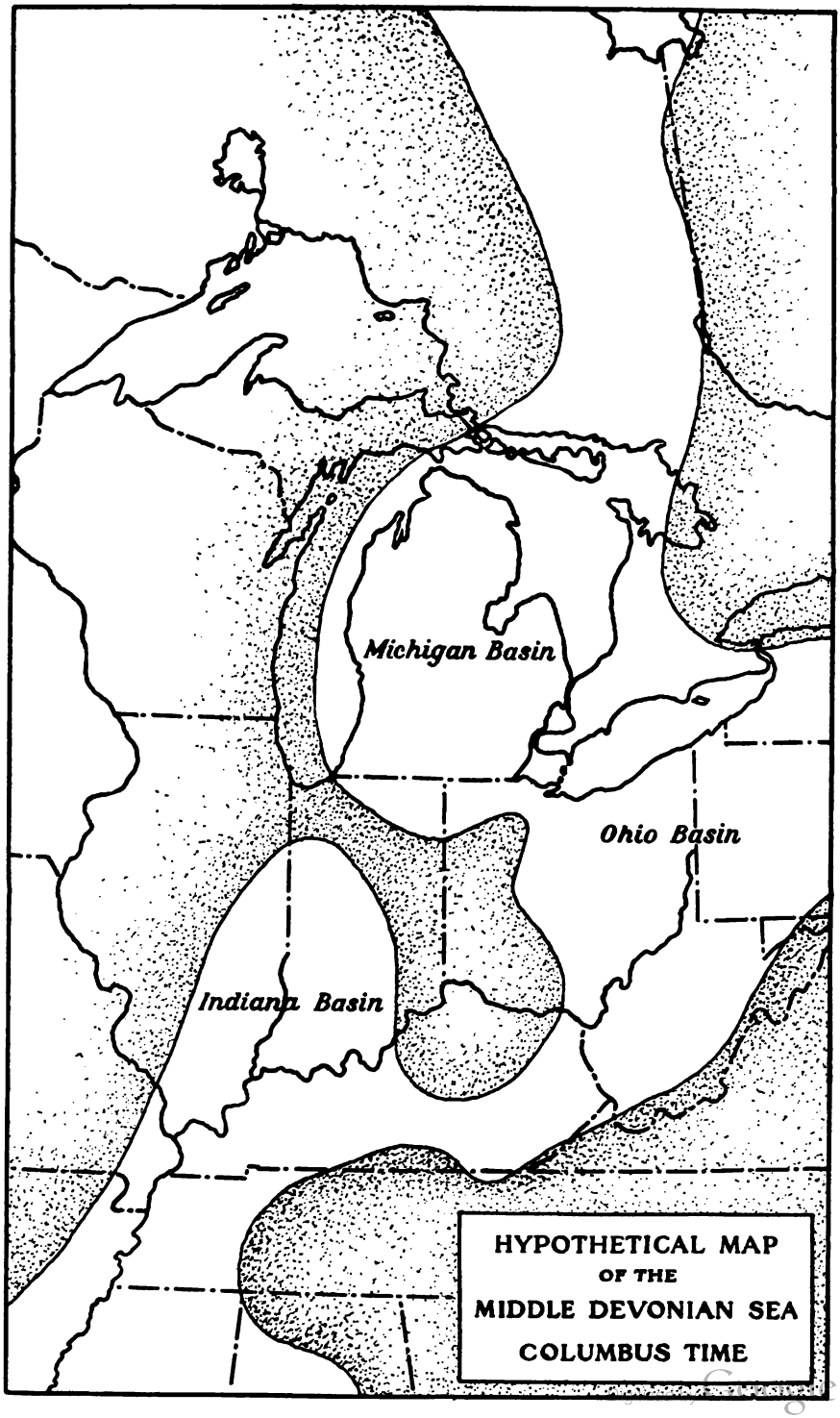
Michigan Basin
Ohio Basin
Indiana Basin
HYPOTHETICAL MAP
OF THE
MIDDLE DEVONIAN SEA
COLUMBUS TIME

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Indiana basin.[1] The thin layers of impure sandy brown limestone representing the Onondaga in the Wabash area of Indiana sometimes fail entirely, and the Hamilton rests unconformably on the Niagara with a bed of ferruginous clay between, as at Delphi, while at a nearby locality the Devonian Black shale rests on the Niagara with a similar bed of clay between.[2] At the northernmost outcrop of Devonian in Indiana, Montecello, the Hamilton (?) consists of a "dark gray to almost black arenaceous limestone."[3]

Hence it is certain that there were islands, and probably a land area, connecting the Cincinnati uplift with the land in Illinois during the Middle Devonian time. It is to be noted also that on this same side of the Cincinnati anticline the Hamilton fauna disappears only about 16 miles south of Louisville, Kentucky,[4] while on the east side the blue shales representing the Olentangy are recognized at Waco and thence occasionally northward into Ohio, but fail entirely at Berea[5] and westward, so that the Black shale rests directly on the Onondaga. There is thus no representative of the Hamilton crossing the axis in Kentucky, although the Onondaga does cross[6] and then fails by overlaps of the Olentangy and Ohio shales on the east side from Fleming county,[7] Kentucky, to Pickaway county, Ohio. The Indiana basin may therefore have been entirely separated from direct communication with the Michigan basin during Onondaga, and from both the Michigan and the Ohio basins during Hamilton time. (See Plates XIV and XV).

CONCLUSION.

Along the east side of this land barrier of Onondaga time, the northern element of the fauna spread southward through Ohio and Kentucky westward into Indiana. This migration was principally that of the Corals, Cephalopods, and fishes together with a less distinctive association of Brachiopods, Pelecypods and Gastropods. Over this same route the southern element, consisting of a different association of Brachiopods, Pelecypods and Trilobites, spread northward. These, at least in part, may have been of South American[8] origin, while others had lived in the region of southern Illinois during Oriskany time.

By the beginning of the Hamilton, the Cincinnati land mass became

[1]Kindle, E. M., 25th Ann. Rept. *Ind. Dept. Geol. and Nat. Res.*, 1900, pp. 562-564.
[2]Kindle, E. M., *Am. Jour. Sci.*, 4th Ser., Vol. XV, 1903, p. 467.
[3]Kindle, E. M., *Op. cit.*, p. 563.
[4]Foerste, A. F., *Geol. Surv. Ky.*, Bull. No. 7, 1906, p. 15.
[5]Foerste, A. F., *Op. cit.*, pp. 104, 105.
[6]Foerste, A. F., *Op. cit.*, p. 16.
[7]Linney, W. M., *Geol. Surv. Ky.*, Rept. on the Geol. of Fleming Co., 1886, pp. 74-76.
[8]For a complete list of the South American Devonian faunas and their relationships, see Thomas, Ivor, *Zeitschr. d. deutsch. Geol. Ges.*, Vol. LVII, 1905, pp. 233-290.

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connected to the south with the land of the Appalachian region; and the connection, in northwestern Indiana, with the land lying to the west, if such connection existed during Onondaga time, was probably broken temporarily, and through this gap immigrants from South America found their way into the Michigan basin. This direct connection was probably of short duration, as some of the characteristic Michigan basin species apparently did not migrate south through it.

Finally at the close of the Hamilton the Interior Continental sea probably succeeded in establishing communication with the Michigan basin by way of Milwaukee, and a mingling of the eastern and western faunas took place, but the conditions which gave rise to the Black shale had set in, and Ohio furnishes no certain evidence of this event.

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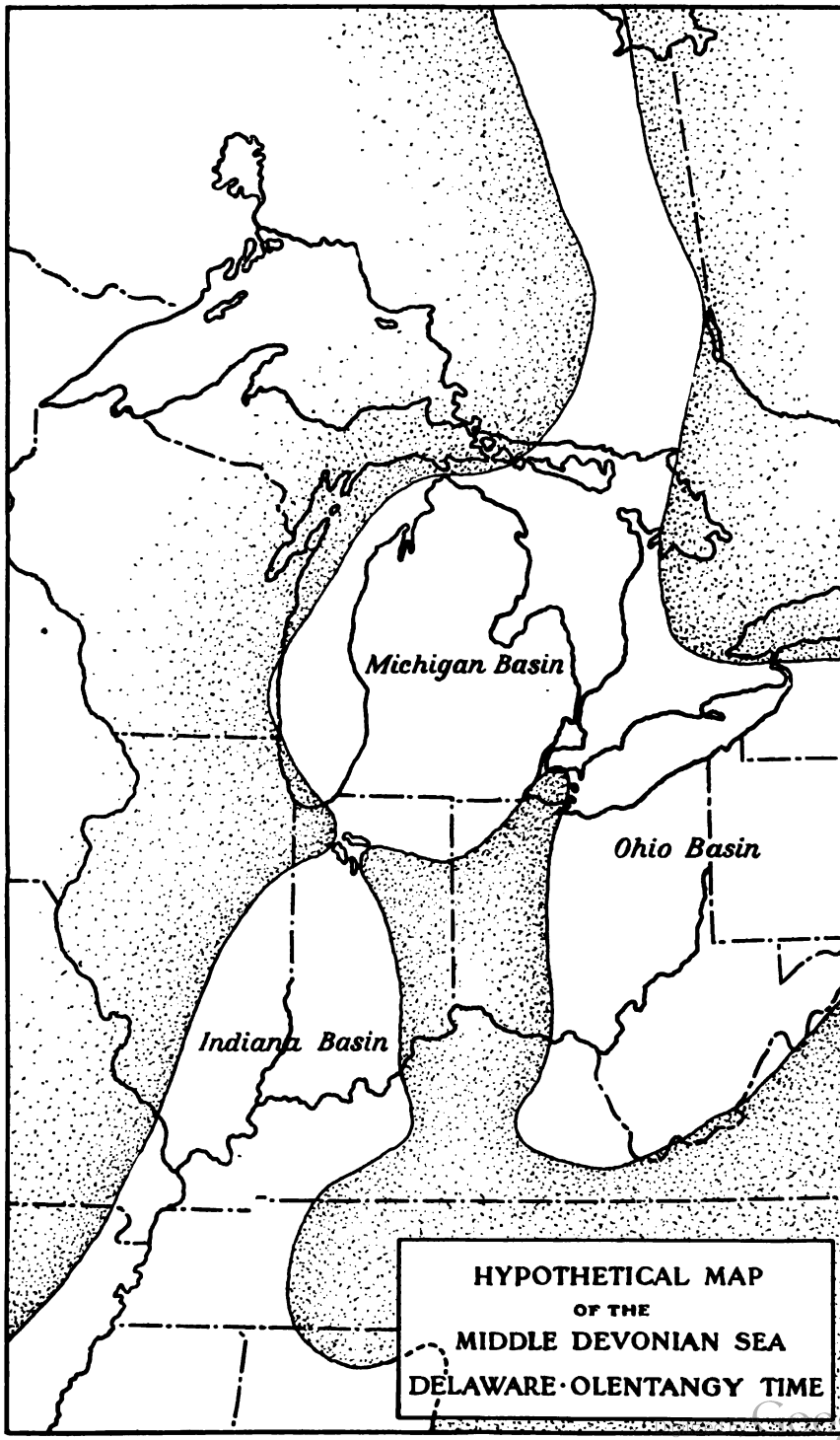
Michigan Basin
Ohio Basin
Indiana Basin
HYPOTHETICAL MAP
OF THE
MIDDLE DEVONIAN SEA
DELAWARE·OLENTANGY TIME

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CHAPTER IV.

INTRODUCTION.

Specimens, which were not capable of specific identification, have been given generic names, where possible, and referred to their proper horizons. This, however, must be given a generous interpretation. If, for instance, *Spirifer sp.* is mentioned as occurring in horizons 1, 2, 3, etc., it does not necessarily mean that the same species occurs in these three horizons, but that an undetermined *Spirifer* has been found in each of the beds thus designated.

The following notes include such observations as have been made during a study of the fossils collected from the Middle Devonian. A certain few specimens have remained unidentified with any published forms. These have been figured and described as new species. Fragments of others have been found which seem also to be new, and hence it is rather certain that the fauna of these formations is still but imperfectly known.

RHIZOPODA.

There is but one *Rhizopoda*, a Foramenifera, known to occur in these formations, and that is *Calcisphæra robusta*[1] of the Columbus limestone. This little fossil has been found from Columbus northward to the lake and less commonly in northwestern Ohio. At Marblehead and on Kelley's Island it occurs in great numbers, often making up a large part of the rock.

SPONGIA.

So far as known, only one species of Spongia, *Receptaculites devonicus* has ever been collected from these formations, and it is rare.

ANTHOZOA.

Corals are abundant in the Columbus limestone and not rare in the Hamilton formations of Ohio. Some of these are probably new, but no good specimens have been collected which are evidently of undescribed species.

[1]*Calcisphæra robusta* Williamson. *Phil., Trans. Roy. Soc. London*, Vol. CLXXI, 1880, p. 523, pl. 20, fig. 81.
This little fossil has been referred to by several writers, chief among whom were Dana and Seward, as the seed of a *Chara*. Williamson, however, was inclined to consider it as a Foramenifera and this is the opinion held by the writer, although the evidence is probably not sufficient to demonstrate either view. The type specimen was taken from Kelley's Island, Ohio.

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HYDROZOA.

Dictyonema is a rare fossil, but *Stromatopora* is abundant in the Columbus limestone, and occasionally is found in the Delaware and Traverse formations.

CRINOIDEA.

Crinoid stems and segments are abundant throughout the fossiliferous portions of these formations. This is especially the case with the Columbus limestone, which is sometimes nothing more than a mass of such remains. The calices, however, are rare and good specimens exceptional.

BLASTOIDEA.

Of the three Blastoids, *Nucleocrinus verneuili* (Troost) is a common fossil in the upper part of the Columbus limestone, while the others are rare. Doubtless some of the stems and segments usually called Crinoid segments are really Blastoid fragments.

BRYOZOA.

Bryozoans are more or less abundant in the Middle Devonian formations of Ohio. Many of them, however, are not well preserved, and hence are beyond identification to the eye not especially trained for the detection of their specific differences. For this reason the lists of species, in the preceding chapters, are relatively too poor in this class of fossils.

BRACHIOPODA.

Athyris vittata indianaensis n. var.

Athyris vittata Hall. Pal. N. Y. Vol. IV, 1867, pl. XLVI, figs. 1-4,

This variety is quite common in the Columbus limestone. It differs too much, however, from the form, which is the type of the species, found at Iowa City, Iowa (13th Rept. N. Y. State Cab. Na. Hist., 1860, p. 89), to be included under the same specific name. It has a much more pronounced fold and sinus, and is less lamellose than specimens from the original locality. Neither does it seem justifiable to identify this species with *A. fultonensis* (Trans. St. Louis Acad. Sci. Vol. I, 1860, p. 650.) This last named species, as found at Iowa City, the type locality, is distinct. It is a much narrower elongate form with the fold and sinus but poorly defined. The above variety name is used to distinguish the Columbus form from that occurring in the Traverse.

Horizon and locality.—Common throughout the Columbus limestone at Columbus, Marion, Sandusky, etc.

Spirifer lucasensis n. sp.

Plate XVI, figs. 1-5.

Shell more or less gibbous, becoming subglobose in the older speci-

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mens. Hinge line equal to or greater than the greatest width of the shell. Cardinal extremities usually not produced. Surface plicated.

The pedicle valve becomes much the more gibbous in the mature shell, although in the young individuals the difference is slight. The curve of the median line of the valve decreases rapidly from beak to front. Beak incurved and approaching that of the brachial valve in older specimens. Area of moderate size and decreasing to the extremities of the hinge line. Mesial sinus well defined, moderately deep, flattened, and with a single angular plication in the center. The front of the sinus is usually much produced.

The branchial valve is convex, with a small incurved beak. Area small and distinguishable only in the central part of the hinge line. Mesial fold well defined and deeply marked by a central depression, or furrow, extending almost or quite to the beak.

Surface marked, on each side of the fold and sinus, by six to ten simple strong angular plications of which the one on either side of the sinus is more pronounced. In well preserved specimens the surface is further marked by lamellose zigzag, imbricating lines of growth.

An average specimen measures .5 inch in thickness, .8 inch in length and .8 inch in width.

This species resembles somewhat *Sp. gregarius*, and possibly Hall's figures 9 and 10, plate XXVIII in Volume IV, Paleontology of New York, of species from the cherts of southern Indiana may be of the same species. It also has a slight resemblance to Hall's *Sp. bimesialis*, and again it resembles *Delthyris consobrina*, but in each case its differences are sufficiently great to separate it easily from them.

Horizon and locality.—This species is quite abundant in the lower part of the Traverse formation, in the quarry of the Whitehouse Stone Company at Whitehouse, Lucas county, Ohio.

Spirifer pennatus (Atwater.)

Terebratula pennata Atwater. Am. Jour. Sci. Vol. II, 1820, p. 244, pl. I, figs. 2, 3.

The variety of *Spirifer pennatus*, so common in the shales along Eighteen Mile Creek, New York, is quite abundant in the soft shales of the Olentangy formation south of Sandusky. Quite a different form occurs in the shaly part of the Traverse formation at Junction, Ohio. Some of these specimens resemble *Spirifer pennatus thedfordensis* (Grabau, Bull. Geol. Soc. Am. Vol. XIII, 1902, pp. 171-176), and probably should be referred to that variety. A few were found, however, which have much coarser imbricating lines of growth, and all have an area which must be described as high, considering the species of which it is a variety. Probably this should be considered as a new variety, and if so the name *Spirifer pennatus auglaizensis* would certainly be appropriate.

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Horizon and locality.—In the soft shales of the Traverse formation, Hager quarry, Junction, Ohio.

Spirifer venustus Hall.

——— ——— Hall: 13th Rept. N. Y. State Cab. Nat. Hist., 1860, p. 82.

Spirifer divaricatus Hall: Pal. N. Y. Vol. IV, 1867, pp. 213, 214, pl. XXXII, figs. 4-8.

This species, which Hall himself repudiated, is doubtless distinct. It differs from the real *Spirifer divaricatus* in its more rounded outline, the much greater number of rounded bifurcating plications and the less angular fold and sinus. It has reached a later stage in the developmental history of the genus, and hence the name is here retained as the specific designation of the Hamilton forms. *Sp. divaricatus* is to be found in the Columbus (Onondaga) limestone throughout the state, but it has never been found to grade into *Sp. venustus*.

Horizon and locality.—Traverse formation, Ten Mile Creek, Silica, Ohio.

PELECYPODA.

Palæoneilo (?) sanduskiensis n. sp.

Pl. XVI, figs. 7, 8.

Shell large and sub-quadrate, length nearly twice the width; posterior extermity obliquely truncated and somewhat pointed; anterior end rounded. Hinge line slightly arched; basal margin nearly straight towards the posterior end, forming an angle of nearly 45° with the cardinal line, and then sweeping around in a broad arch, over the last two-thirds of its length, to the hinge line.

Valves convex with the greatest gibbosity in front of the small beaks, and which latter are somewhat in front of the middle of the hinge line. The posterior portion of the shell decreases in convexity gradually until a little more than half way to the end, where there is a sudden decrease in the same. The valves were probably thin, as shown by the preservation of surface characters and of strong adductor muscular impressions.

Surface marked by well defined concentric lines of growth.

Horizon and locality.—Lower part of the Delaware limestone, Wagner quarry No. 1, Sandusky, Ohio.

GASTROPODA.

Bellerophon hyalina Hall.

Pl. XVII, figs. 3, 4.

——————— Hall: Pal. N. Y. Vol. V, pt. II, 1879, p. 99, pl. XXVI, fig. 4.

This species is quite common in the chert beds of the Columbus limestone, and might have been described as a new species were it not

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for a provisional statement which Hall makes in his description. He says that "although no dorsal band has been observed, it is possible that such a feature may exist in better preserved specimens."

The specimens collected show a well defined slit band which is limited on either side by a nearly plain concave surface and ornamented in the central part by the same cancellated striæ characteristic of the remainder of the shell. Of the revolving striæ in the slit band there are usually four or five.

The type of this species was collected in the cherty layers of the Onondaga limestone near Jamesville, Onondaga county, N. Y., where the "association of species is, in many respects, extremely similar to that of the cherty beds at Dublin, Ohio."

Horizon and locality.—The chert zone of the Columbus limestone at Dublin, Eversole Run, etc.

Macrochilina hebe Hall.

———————— Hall: Pal. N. Y., Vol. V, pt. II, 1879, p. 32, pl. XII, figs. 4–7.

All of those specimens collected and which have been referred to this species are small (as is frequently the case with a large part of the fauna of the chert zone) and possibly the spire is a little more elevated than in the type figures, but otherwise they agree very well with Hall's figures and descriptions.

Horizon and locality.—Chert zone of the Columbus limestone, Eversole Run, Ohio.

Murchisonia eversolensis n. sp.

Pl. XVI, fig. 13.

Shell elongate turriteliform; spire angle 30°. The portion preserved lacks perhaps three or four whorls from the apex, is two-fifths of an inch long at a place where the basal measurement is one-quarter inch, and has three rather closely coiled laterally flattened volutions.

The surface is marked by a plain spiral band and by a few rather indistinct concentric striæ which swing backward towards the band and then forward to the columella. Suture line distinct and well up towards the band.

Horizon and locality.—The chert zone of the Columbus limestone, Eversole Run.

Murchisonia intermedia n. sp.

Pl. XVI, fig. 9.

Shell moderately elongate, sub-fusiform; angle of spire about 48°; volutions rounded and, in the specimen figured, five in number.

Surface marked by strong concentric striæ, bending back gently to the slit band which they show no evidence of crossing. The band is limited above and below by very pronounced sharp carina, and the center of the band marked by a series of papillæ or knot-like elevations

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caused by the meeting of the growth lines or striæ, which are more numerous than on either side of the band.

This species may be compared with both *M. leda* and *M. maia*, being somewhat intermediate between the two.

Horizon and locality.—Rare in the chert zone of the Columbus limestone, Eversole Run, Ohio.

Murchisonia quadricarinata n. sp.

Pl. XVII, figs. 10, 11.

Shell with a very high spire. Spire angle about 20°. Seven to ten or more rather closely coiled volutions which increase in size gradually from apex to base. Aperture probably sub-quadrate in outline.

Surface marked with four carina which simulate a revolving slit band, but probably only the inner two represent that feature. As a further surface ornamentation there are numerous concentric striæ which start at the suture, sweep over a pseudo-carina and are lost near the upper carina. The suture usually covers the lower carina.

Horizon and locality.—Chert zone of the Columbus limestone at Dublin and Eversole Run, Ohio.

Platyceras blatchleyi Kindle.

Pl. XVI, figs. 11, 12.

———————— Kindle: 25th Ann. Rept. Dept. Geol. and Nat. Res. of Ind. 1900, p. 733, pl. XVII, fig. 6.

The specimen here figured probably belongs to this species, but it shows some important variations. The shell is more erect and its apex closely enrolled for more than a complete volution. Along the compressed angular dorsum there are probably fewer spines (only three preserved) and these curve off rapidly to the left of the shell instead of being directed straight backward. The right side is considerably expanded while the left is nearly flat. And finally, the surface is marked by wavy concentric lines of growth which suggest that the margin was probably crenate.

Horizon and locality.—Upper part (Zone H) of the Columbus limestone along Indian Run at Dublin, Ohio.

Platystoma subglobosa n. sp.

Pl. XVI, fig. 6.

Shell subglobose in shape; spire but slightly elevated; angle of spire 112°; six volutions, of which four are exceedingly small, are shown. The body whorl is much expanded and makes up more than five-sixths of the entire shell. Suture shallow. Aperture circular; the outer lip thin, the inner reflexed over the umbilicus, forming a callosity.

Surface marked by rather indistinct striæ parallel to the outer edge of the lip; occasionally these striæ are crowded together and more pronounced.

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Horizon and locality.—The chert zone of the Columbus limestone Eversole Run.

Pleurotomaria cancellata n. sp.

Pl. XVII, figs. 1, 2.

Shell somewhat depressed; spire angle 92° in the specimens figured; from four to five depressed rounded volutions. Aperture subquadrate and with no true columella; umbilicus covered by the callosity of the inner lip.

Surface marked by strong concentric and revolving striæ which form a lattice-like pattern, best observed on the lower part of the body whorl. There is also a well defined slit band and two prominent carina present on either side of the band with its minor limiting carina. From the suture to the upper carina the concentric striæ are strong and swinging backward are crossed by only a few revolving striæ, but these sometimes have the appearance of secondary carina and may even be reduced to one. After crossing the carina the concentric striæ are much less prominent, but three or four times as numerous. Crossing the slit band with an arc-like course (concave foreward) and no median carina, the concentric striæ swing forward to a sharp carina similar to that above the band, lose two-thirds or more of their number and converge to the umbilicus. On this lower part of the body whorl, the concentric striæ increase by implantation.

Compare this species with *P.* (*Bembexia*) *sulcomarginata* Hall.

Horizon and locality.—Rather common in the chert zone of the Columbus limestone, Eversole Run.

Pleurotomaria dublinensis n. sp.

Pl. XVII, figs. 7, 8, 9.

Shell conical; angle of spire about 47° in the specimen figured. Four rather rounded volutions preserved and probably three missing. Aperture somewhat quadrate but inclined to be rounded.

Surface marked by concentric striæ which appear to be simple radiate from the well defined suture and then curve slightly backward to the slit band. Below the band the striae make but a slight forward curve and then converge to the umbilicus. The slit band is sharply defined on either side by a carina and there seems to be no markings within the band.

All specimens of this species collected were exceedingly small. The larger specimen figured is about one-eighth of an inch in length.

Horizon and locality.—The chert zone of the Columbus limestone at Dublin and also along Eversole Run.

Pleurotomaria hyphantes Meek.

——— ——— Meek: Geol. Surv. Ohio, Vol. I, pt. II, Pal., 1873, p. 227: pl. XX, fig. 6.

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Meek figures and describes this species referring it doubtfully to *P. lucina*. He concludes his description, by saying that "should it prove to be distinct, however, it might be designated as *P. hyphantes*, in allusion to its beautiful textile style of sculpturing." The specimens of this species collected are excellent and are certainly not *P. lucina*. Its spire is higher, the inner lip of the aperture is more extended, and the band, as well as the general surface of the shell, is more highly ornamental.

Horizon and locality.—The chert zone of the Columbus limestone. Dublin, Deer Run, Eversole Run, etc. Ohio.

Pleurotomaria sciotoensis n. sp.

Pl. XVII, figs. 5, 6.

Shell higher than wide, conical in outline; spire angle 71°; five volutions preserved, the last one considerably expanded.

Surface marked by strong concentric striæ or ridges which often bifurcate on the lower side of the body whorl. The surface is further marked by a sharply carinated revolving band, limited above and below by less conspicuous marginal carina; also there is a sharp carina midway between the band and the suture line while below the band there is a similar sharp carina at about the same distance. The concentric striæ start straight out from the suture line and then swing backward, bending forward again just before reaching the first carina. They then swing backward rapidly and sometimes bifucate and become less conspicuous as they reach the slit band. The concentric markings on the band do not definitely connect with those outside and may be either of the same number or more numerous. Below the band the striæ swing forward towards the lower carina and do not show the same tendency to bifurcate; after passing the carina they converge towards the umbilicus and many of them unite before reaching it. Umbilicus closed by a callosity.

This species should be compared with Hall's *P. triplex* of the Hamilton.

Horizon and locality.—The chert zone of the Columbus limestone, Eversole Run, Delaware county, Ohio.

Straparollus corrugatus n. sp.

Pl. XVI, fig. 10.

Shell turbinate with spire depressed at the apex; spire angle about 90°. Five rounded whorls, the lower of which is somewhat depressed. Aperture circular; umbilicus large.

Surface marked by rather strong and medium coarse transverse or concentric striæ which suggest corrugations of the shell.

Horizon and locality.—The chert zone of the Columbus limestone, Eversole Run.

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CEPHALOPODA.

Cyrtoceras metula (?) Hall.

——— ——— Hall: Pal. N. Y. Vol. V, pt. II, 1879, pls. XLVII, figs. 1, 2, and CXI, fig. II, p. 360.

The surface of the test of this specimen is marked by fine transverse striæ of growth which curve slightly toward the posterior, dorsally to the siphuncle.

Horizon and locality.—The chert zone of the Columbus limestone, Eversole Run.

Orthoceras ohioensis Hall.

——— ——— Hall: Pal. N. Y. Vol. V, pt. II, 1879, p. 236, pl. XXXV A, figs. 8, 9 and also pl. XXXVI, fig. 4.

The surfaces of most of these specimens are smooth and show no indication of the chambered interior. One specimen, however, is partly exfoliated and shows the interior nicely. Another specimen shows a trace of the original color.

Horizon and locality.—The chert zone of the Columbus limestone, Deer Run, Eversole Run, etc.

CRUSTACEÆ.

Dalmanites.

Upon the advice of Dr. Weller, the sub-genera of *Dalmanites* have been recognized as of full generic rank. They are certainly of sufficient importance to be readily recognized as constituting well defined specific groups and doubtless deserve the rank here given them.

Proetus welleri n. sp.

Pl. XVII, figs. 12, 13.

Outline of entire body oval, the greatest length being nearly twice the greatest width (1.22 inch long and .64 inch wide.)

Cephalic shield crescent shaped and moderately convex; genal angles produced into spines marked by a few indistinct striæ on the under side. Free cheeks separated from the fixed cheeks by a suture which curves rather abruptly outward from the front of the eye, and then swings towards the median line before cutting the outer margin, making thus a more complete double curve than usual. A well defined glabella moderately convex, short and tapering rapidly to a rounded front, which fails to reach the frontal margin by fully one-third of the length of the cephalon. The glabella is exfoliated and shows the primitive five furrows, although the anterior pair is rather indistinct and transverse while the posterior furrows are directed backward. Occipital lobes large, eyes of medium size and moderately convex.

Thorax of ten segments; the axis narrow, strongly convex and tapering gradually to the pygidium; the pleura rather flat from the axis

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to about half the distance to the margin, where they curve abruptly downward.

Pygidium semicircular, not distinctly emarginate; length about two-thirds the width and nearly one-third the entire length of the body. The axis diminishes in convexity rapidly from the point of union with the thorax and terminates bluntly one-tenth of an inch within the margin, Twelve annulations on the axis. Pleura convex and not flattened near the axis, nine divisions may be counted and these become obsolete before reaching the border.

This species is named in honor of Dr. Stuart Weller, in appreciation of his interest in the fauna.

Horizon and locality.—The upper part of the Columbus limestone in the Lake Shore Railroad quarry south of Venice, Ohio.

PISCES.

Dipterus eastmani n. sp.

Pl. XVII, figs. 14–17.

An upper dental plate which is more or less triangular in outline and rather more convex than usual for the genus. It is chiefly characterized by the appearance of but three major denticulated ridges, in front of which there are at least three other similar but rather inconspicuous ridges. There are from six to eight denticulations preserved on the major denticulated ridges and apparently from three to five on the indistinct minor ridges. The coronal surface is well worn and shows punctations. The anterior end of the plate is somewhat extended beyond the coronal surface and tapers gradually to the front. This latter is probably a remnant of the pterygo-palatine bone.

There is reason to believe that this specimen is fragmentary, but the portion preserved measures 1.6 inch in length, and .8 inch in width It should be compared with *D. uddeni* (N. Y. State Mus. Mem. 10, 1907, p.160, pl.IV, figs. 3, 4), from which it differs in the number of denticulated ridges and in general outline.

This species is named in honor of Dr. Charles R. Eastman, who has contributed so much to our knowledge of the fossil fishes of North America.

Horizon and locality.—This specimen was found in the zone from five to ten feet below the top of the Columbus limestone in the quarry of the Whitehouse Stone Company, at Whitehouse, Ohio.

Note:—The types of the species above described may be found in the Geological Museum of the Ohio State University.

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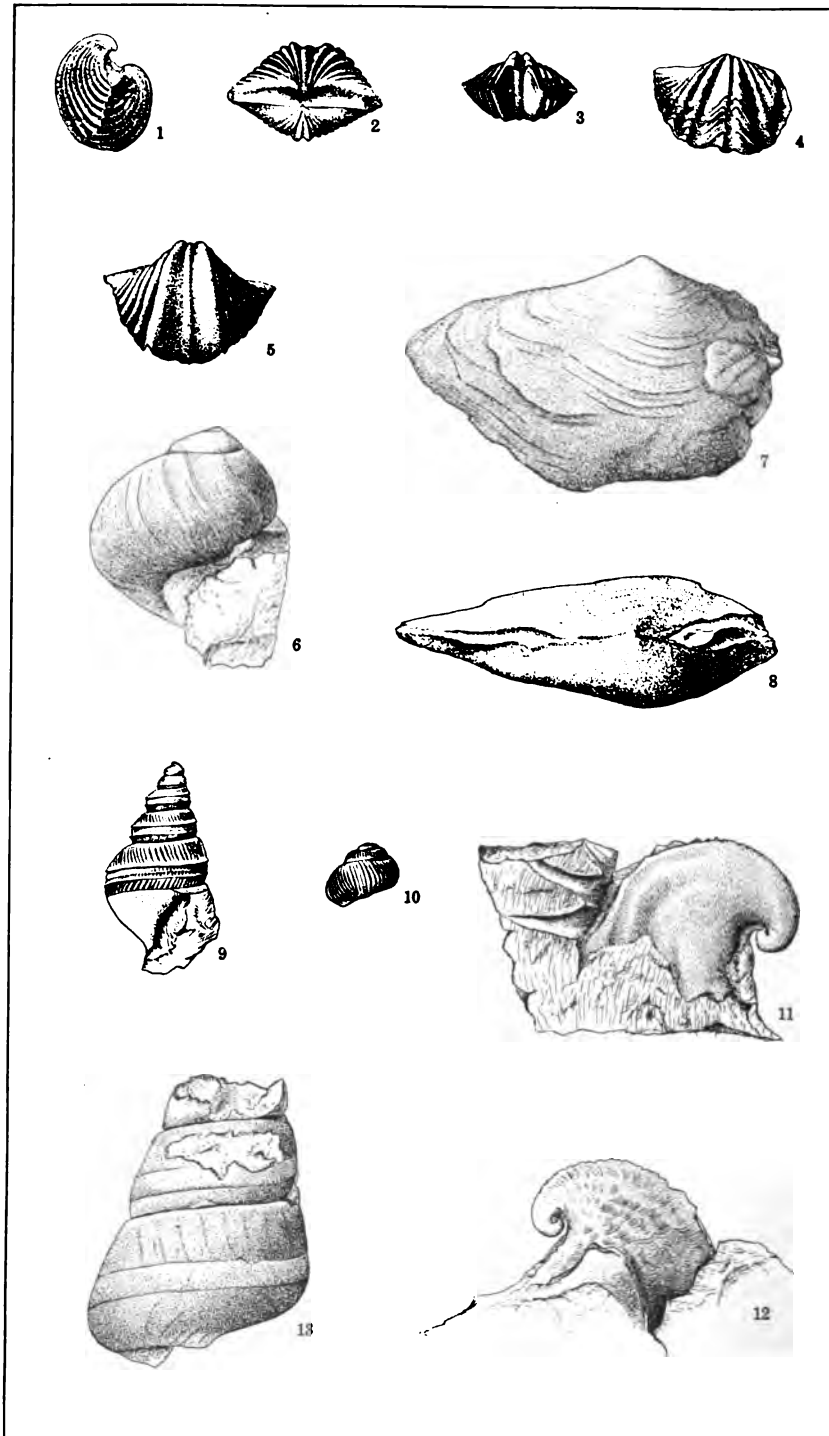
PLATE XVI.



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EXPLANATIONS OF PLATES.

PLATE XVI.

Page.

Figs. 1-5. *Spirifer lucasensis* n. sp..... 188, 189

1. Lateral view showing the gibbosity of a medium sized individual; natural size.
2. Posterior view of a smaller specimen; natural size.
3. Anterior view showing plication in fold and sinus; natural size.
4. Brachial valve of No. 1. This shows the lamellose imbrication of a portion of the exterior surface preserved; natural size.
5. Pedicle valve of a large individual; natural size.

Fig. 6. *Platystoma subglobosa,* n. sp..... 192, 193

6. This is a very good representation of the only specimen collected; enlarged four diameters.

Figs. 7, 8. *Palæoneilo* (?) *sanduskiensis* n. sp..... 190

7. A view of the right valve of a specimen which is, in part, a mould of the interior; natural size.
8. Hinge line of the same specimen, natural size.

Fig. 9. *Murchisonia intermedia* n. sp..... 191, 192

9. A view showing the general form and ornamentation of this species; enlarged four diameters.

Fig. 10. *Straparollus corrugatus* n. sp..... 194

10. General form and ornamentation of the only specimen collected; enlarged four diameters.

Figs. 11, 12. *Platyceras blatchleyi* Kindle..... 192

11. A view of the exfoliated left side showing some of the spines; natural size.
12. A portion of the shell on the right side, showing the surface markings; natural size.

Fig. 13. *Murchisonia eversolensis* n. sp..... 191

13. This view shows the plain character of the surface markings of this species; enlarged four diameters.

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PLATE XVII.

Page.

Figs. 1, 2. *Pleurotomaria cancellata* n. sp..... 193

1. A nearly complete specimen showing the beautiful cancellated ornamentation; enlarged four diameters.
2. Another specimen showing a portion of the aperture; enlarged four diameters.

Figs. 3, 4. *Bellerophon hyalina* Hall..... 190, 191

3. A specimen showing an excellent preservation of surface characters and especially of the slit band; enlarged four and one-half diameters.
4. Lateral view of the same specimen; enlarged four and one-half diameters.

Figs. 5, 6. *Pleurotomaria sciotoensis* n. sp..... 194

5. A specimen showing the ordinary surface characters; enlarged four diameters.
6. A specimen showing a portion of the aperture and a finer marking of the slit band; enlarged four diameters.

Figs. 7-9. *Pleurotomaria dublinensis* n. sp..... 193

7. A specimen preserving a portion of the aperture; enlarged five diameters.
8, 9. Several smaller specimens showing somewhat coarser surface markings; enlarged four and one-half diameters.

Figs. 10, 11. *Murchisonia quadricarinata* n. sp..... 192

10. A specimen showing the high spire and turritella-like ornamentation; enlarged five diameters.
11. A small specimen in which the four carina are better preserved; enlarged four and one-half diameters.

Figs. 12, 13. *Proetus welleri*, n. sp..... 195, 196

12. A view showing the glabella and a small portion of the remainder of the cephalon; enlarged two diameters.
13. A portion of the thorax, the pygidium and a genal spine of the same specimen; enlarged two diameters.

Figs. 14, 17. *Dipterus eastmani* n. sp..... 196

14. Top view of the oral surface; natural size
15. A semi-lateral view of the oral surface; natural size.
16. Outer lateral view; natural size.
17. Inner lateral view; natural size.

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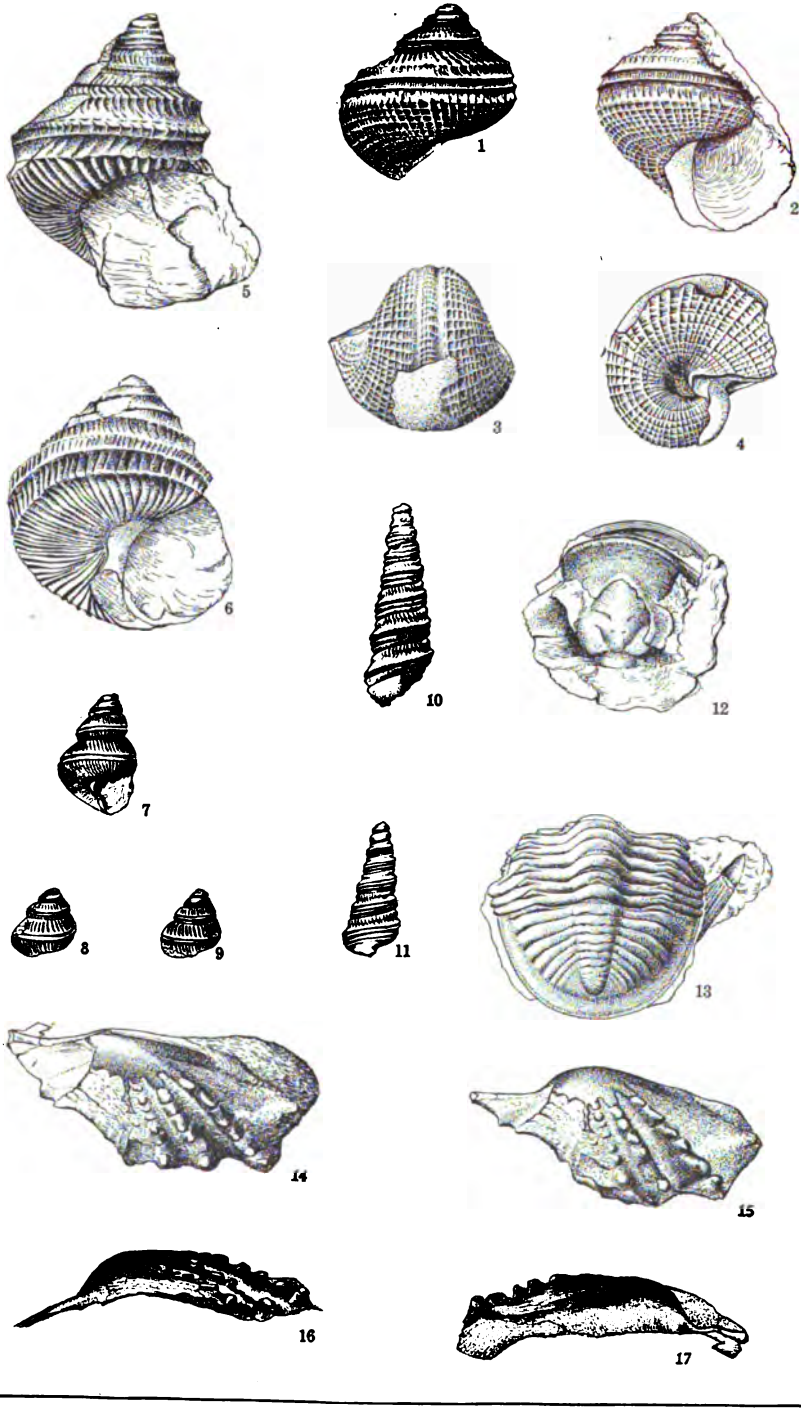

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